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Biological Studies on Common Chickweed (*Stellaria media*)

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Biological Studies on Common Chickweed (*Stellaria media*) submitted by Joan Amundsen in partial fulfilment of the requirements for the degree of Master of Science in Weed Science.

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Abstract

Common chickweed (*Stellaria media*) has become a serious problem for farmers in north-central Alberta in recent years. Results of biological studies on the species are presented here.

Germination of fresh chickweed seeds varied with seed lot. Gibberellic acid was very effective in overcoming seed dormancy, but the effectiveness of potassium nitrate varied with seed lot and length of storage of the seed. Dormancy characteristics did not seem to be inherited. Dormancy was overcome within one month when seeds were stored under cool, moist conditions. The optimum temperature for chickweed germination was 15 to 20°C, and few seeds germinated at 3°C or at 25°C. Application of potassium nitrate to the soil increased germination. The optimum depth of seeding was 0.5 to 1.0 cm. Emergence decreased with depth of seeding and no seedlings emerged from 5 cm.

Field-grown chickweed flowered 40 days after emergence. Flowering was indeterminate and continued for 4 to 5 weeks in early summer. Pod and seed development was rapid and viable seeds were produced 9 days after flowering. When flowering was complete, the branches senesced but new branches arose from near the base of the plant and produced flowers in September. The plants survived freezing temperatures in the fall, but only the tips of the branches remained green. Chickweed did not survive as a winter annual

in the Edmonton area.

Dry matter production by chickweed plants increased with increasing light intensity. Plants grown at low light intensities branched very little and were green and weak-stemmed, while those grown at higher light intensities branched freely and were compact with short internodes, stiff, reddish stems and small leaves.

Growth of chickweed was reduced as temperature increased from 8°C to 30/20°C. The form of the plant was altered when chickweed was grown at 30/20°C. Plants placed in a 30°C incubator died.

Chickweed growth was reduced with a reduction in available soil water.

Dry matter production per pot increased up to a density of 10 to 25 plants per pot, but further increases in density up to 100 plants per pot did not result in any additional increases in dry matter production per pot. As expected, increasing chickweed density resulted in reduced barley dry matter production when the two species were grown in competition. Time of emergence of the chickweed was very important to competition between the two species. When chickweed emerged 2 weeks before the barley, barley growth was severely limited regardless of chickweed density.

Chickweed was controlled with linuron/MCPA, cyanazine/MCPA, and A5633 alone or in combination with MCPA, whereas metribuzin and DPX 4189 also provided residual control. Mecoprop/bromoxynil was effective if a high rate of

mecoprop was included. Dicamba/MCPA and propanil/MCPA did not control chickweed.

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I wish to acknowledge the advice and support given by Dr. W.H. VandenBorn during the course of my studies.

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Table of Contents

List of Tables

List of Figures

I. Introduction

Weeds interfere with crop production in many ways. Competition for light, water and nutrients may reduce the yield and quality of the crop. Weeds can also pose mechanical problems in harvesting operations and act as alternate hosts for disease organisms and insects (23). In order to minimize these problems, we must understand the growth habits of weeds so that we may design effective control programs.

Common chickweed (*Stellaria media*) is listed as a noxious weed under the regulations of the Weed Control Act in Alberta (3). It has become a serious problem to farmers in north central Alberta in recent years. Few studies have been carried out in the prairie provinces regarding the growth and competitiveness of chickweed. This project was initiated, therefore, to provide information on the growth of chickweed in north central Alberta, and its competitive behaviour in crops.

II. Literature Review

A. Distribution and Habitat

Chickweed is a native of Eurasia, but has become one of the most widespread weeds in the world (21). It has travelled with man for centuries. Evidence of this comes from northwestern Europe where seeds of the species were found in the stomachs of the Tollund man and the Graubelle man, dated at the third to fifth century A.D. (21).

Chickweed is found on every continent and is absent from only the most Arctic regions and from very dry areas. It occurs at tropical latitudes, but only at high elevations (48). Chickweed prefers cool, moist, shady locations and grows on most soil types (21). It does best on a heavy nitrogen rich soil with pH in the range of 5.2 to 8.2, but it has been found growing on soil with pH 4.8. Growth was reduced on acid soils, likely due to aluminum toxicity (23,48).

Chickweed occurs as a weed in a great variety of crops throughout the world. It is a weed of cereals, forages, pastures, sugar beets, vegetable crops, small fruits, citrus, sugar cane, coffee, hemp, orchards and vineyards. It can create special problems in perennial, winter annual or early-planted spring crops, as it begins growth very early in the spring. It is one of the most common weeds of spring and winter cereals in northern Europe and in the Hokkaido

region of Japan (21). Chickweed was reported, in 1979, to be a principal weed in 21 countries, present as a weed in 26 more and a part of the native flora in an additional five countries (22).

In Canada, chickweed has been reported present in all provinces, as well as in the Yukon and District of Mackenzie. It was found in Alaska as far north as 68°N, and has been introduced in Greenland (40). It was more common in British Columbia and eastern Canada than in the prairie provinces (48).

Chickweed infested an estimated 1.4 million hectares in Alberta in 1980 (13). The area of heaviest infestation was in north-central Alberta, where about 40% of the cultivated land was infested. Scattered infestations occurred in the south-central and Peace River regions.

B. Description

Chickweed is an annual, winter annual or sometimes a perennial herb. The stems are 5 to 40 cm long, much branched and may be decumbent or ascending. A single line of hairs occurs along each internode. The leaves are opposite, glabrous and entire, the lower ones being 3 to 20 mm long, ovate and stalked with a line of hairs on the petiole. The upper leaves are larger, up to 30 mm long, broadly elliptic and sessile or slightly petiolate. Flowers are numerous and are borne solitary in leaf axils, or in terminal cymes. They have three styles, three to ten stamens, five sepals and

five petals. The sepals are 4 to 6 mm long and hairy. The petals are white, deeply bifid and somewhat shorter than the sepals. The capsule is obovoid, slightly longer than the calyx and opens by six valves at maturity. It contains eight to ten reddish-brown seeds that are 0.9 to 1.3 mm in diameter, flattened and tuberculate (8,21,28,29).

C. Seed Germination

Seed dormancy and longevity are factors that affect the persistence of weed seeds and therefore affect the ability of weeds to infest croplands. A seed is considered dormant if it is viable but will not germinate when placed under conditions usually suitable for germination (32,45). In many cases, seed dormancy decreases slowly with dry storage at room temperature (45). Some seeds require stratification, a low temperature treatment of imbibed seeds, to overcome dormancy (32,45). Exposure to light may also be effective in breaking seed dormancy in some species, especially after the seeds have been buried (43,52). Each plant species has a range of temperatures that are optimum for germination. In many cases, alternating temperatures are found to promote germination (31). The addition of nitrate (17,32) or gibberellic acid (10,45) to the germination medium may also promote germination in some species.

In chickweed, dormancy was lost slowly when the seeds were stored dry. Roberts and Lockett (34) tested germination under a range of constant and alternating temperatures with

and without the addition of potassium nitrate. Germination increased to some extent after the seed had been stored for 36 weeks, regardless of germination conditions. In most cases, some increase in germination was noted after 4 or 14 weeks of dry storage. In other studies, seed that initially germinated 33% increased to 70% germination after 30 months dry storage (15) and seed with a germination of 16% two weeks after harvest, germinated 52% after 6 months dry storage (10). Chickweed seed lost dormancy during dry storage, but the time required, and the extent of dormancy loss varied with germination conditions and seed lot.

Burial in the soil provides more favorable conditions for loss of dormancy than does dry storage. An appreciable increase in chickweed germination was observed after burial of seeds for 4 weeks. After 14 weeks, germination of exhumed seed was almost complete (34). Taylorson (44) found that chickweed seeds which were dormant when fresh germinated less than 20% after being buried for 3 months, but germination after 6, 9 and 12 months was near 100%.

A study done in Kentucky (5) where chickweed behaves as a winter annual, showed that imbibed seeds did not lose dormancy when held at 5 to 10°C and no germination occurred when they were transferred from these conditions to an environment favorable for germination. Temperatures of 20°C or higher were required for afterripening of imbibed seeds in this study. This high temperature requirement for afterripening provided a mechanism which ensured that the

seeds would germinate at a time that was most suitable for growth of the plants, that is, in the fall. Afterripening conditions likely vary depending on the adaptation of the plant to its environment. Where chickweed behaves as a summer annual, seeds could be expected to lose dormancy at lower temperatures such as those experienced in the fall and winter, to ensure spring germination.

Chickweed germination has been enhanced by the addition of 0.2% potassium nitrate to the germination medium (2,34). The addition of nitrate fertilizer to soil did not significantly stimulate germination of four species tested (17,39), however, laboratory germination of lambsquarters seed harvested from nitrate-treated plots increased over the control (17). Chickweed was not included in these experiments.

Gibberellic acid was reported to be active in overcoming dormancy in some species (2,10), but germination of chickweed was not affected by presoaking with 500 or 1000 ppm GA (10).

Interactions between factors can be very important in breaking seed dormancy. Roberts and Lockett (34) observed that fresh chickweed seeds would not germinate except when given 0.2% potassium nitrate, an alternating temperature regime and intermittent light. When only one or two of these factors were present, they had no effect on germination of fresh seeds. In contrast, Andersen (2) reported 71% germination when 1 month old seeds were exposed to 0.2%

potassium nitrate at a constant temperature of 20°C. No mention was made of lighting conditions. Whereas interactions between factors seem to be important in loss of seed dormancy, the origin and treatment of the seed is also important.

Germination of fresh chickweed seeds was stimulated when soil was used as a substrate rather than filter paper (2), possibly due to the presence of nitrate in the soil. The optimum depth of seeding, in the field (2) and in a laboratory study (14), was 0.5 to 1.2 cm. In the field, few seedlings emerged from 2 cm, but in the laboratory study some emerged from 5 cm. No seedlings emerged from 7.8 cm in the latter study.

Germination of fresh chickweed seeds does not seem to be promoted by light and may be inhibited by strong illumination (34), but seeds that have been buried in soil for some time develop a light requirement for germination. In the field, a large flush of germination of weeds including chickweed occurred after disturbance of cultivated land that had been in pasture for 6 years (51). This was attributed to the loss of dormancy by buried seed when it was exposed to light. Subsequent studies (43,44) showed that burial of seeds that did not require light for germination, including chickweed, induced a light requirement. Taylorson (43,44) showed that light-induced germination of seeds after burial was the result of a phytochrome response. In some species, including chickweed, it appeared that germination

was stimulated by very small changes in the P_{fr} level and therefore the seeds were sensitive to small amounts of light. This conclusion is supported by the observation that low-intensity green light from a safe lamp promoted germination of buried chickweed seeds, over a dark control (6).

The optimum constant temperature for germination of chickweed seed was found to be in the range of 12°C to 20°C (34). Germination was reduced at 25°C and higher. Some germination occurred at 2°C to 5°C but it was slow at these temperatures (24,34). Alternating temperatures enhanced germination and may be required for germination of fresh seeds (34).

Seeds that are buried in the soil may remain viable for a considerable length of time. In general, increasing depth of burial or placement in acid or waterlogged soils favor dormancy and survival of the seeds (15,43). In Dr. Beal's seed viability experiment, some chickweed seeds germinated in the thirtieth year after burial but not in the thirty-fifth year (12). Chickweed seeds buried in the Duvel seed experiment were viable after 10 years but not after 16 years (47). Viability was lost most quickly at the shallowest of the three depths of burial included in this experiment. In a more recent study in Mississippi (15), the viability of chickweed seed was reduced after burial for 6 months and after 30 months no viable seed remained. This relatively short period of viablilty, in comparison with

other studies, may be due to the hot, humid summers experienced in that region or to differences in the conditions of burial between the experiments. In the latter experiment, the seeds were buried in a manner that more closely resembled a natural situation than that of the two earlier experiments. Field studies of weed seeds, including chickweed, buried in a British soil (33) showed that the number of viable weed seeds declined exponentially whether the soil was cultivated or not, however, the decline was most rapid when the soil was cultivated.

Plant species have varying requirements for overcoming dormancy; therefore, the emergence of seedlings is distributed over time. This distribution in time may also be related to seed location in the soil and related temperature, moisture and aeration differences. Many species tend to have two peaks of germination in the spring and fall (32,46). Roberts and Ricketts (35) found that weed seedlings that emerged following a cultivation accounted for 3 to 6% of the soil seed population. Emergence of chickweed was higher following cultivations in the spring and fall than following cultivation in the summer (23,33).

D. Growth and Reproduction

Chickweed is reported to be a pioneering species that grows best in new or disturbed communities and is capable of colonizing bare areas very quickly (21,48). The plants are quite variable and therefore are adaptable to a variety of

habitats. Fall seedlings behave as winter annuals in southwestern British Columbia and in England, where winters are moderate (48). In more severe climates, such as northern Alberta, chickweed overwinters only as seed.

Chickweed can grow rapidly and sometimes produces several generations in a year (21,48). Plants are capable of rooting from the nodes where the stems touch moist ground (47). Chickweed begins to flower 4 to 5 weeks after emergence (53) and flowering is continual. The flowers are self-pollinated (37) and they open and close only once, lasting about one day. When the plants are in the reproductive phase, there are usually flowers and seeds on the plant, in all stages of maturity. The plants have eight to ten seeds per capsule and the average seed production has been estimated at 2400 (37) to 2900 (19) seeds per plant. Seed production by the largest plant in the experiment by Salisbury (37) was estimated at 13,000 seeds. In Sweden, Foglefors (19) estimated production of 388,600 seeds per m^2 in the field, at an experimental density of 135 plants per m^2.

Several estimates of the number of chickweed seeds present in the soil have been given: 8.3 million per hectare (35), 11 to 13 million per hectare (21), and 4.4 million viable seeds per hectare in arable land (23).

Chickweed has been reported to grow and flower at temperatures down to 2°C (48) and to survive temperatures as low as -10°C (21), but no mention was made of the length of

time it was able to survive these low temperatures. Chickweed has been reported to flower and produce seed throughout the year in climates where it grows through the winter. Flowers produced in the winter were apetalous and cleistogamous, but they were self-pollinated and produced fertile seeds (21,23). Although chickweed seems well adapted for cold survival, it was unable to withstand hot, dry conditions and died back if such conditions persisted (48). The optimum temperature for laboratory culture of chickweed was 22°C (49).

Foglefors (18) showed that chickweed had a good physiological adaptation to low light conditions, and was capable of flowering and producing seed near its light compensation point but the light compensation point was not stated. In a study in Japan (24), the light compensation point for chickweed was about 10 klux.

E. Competition

The principle of Gause, first stated in 1934, considered plant interactions in two situations. It stated that if two plants were competing for the same resources in the same space, only one of them would survive. On the other hand, if two plants differed in their needs for space, time or resources, even if some of these needs overlapped, they could coexist (9). Competition was defined by Bleasdale (7) as a situation where the growth or form of one or both of the competitors was different from that of an individual

grown alone. This definition considers a situation where competing plants can coexist as stated by Gause, but recognizes that they do have an effect on one another.

Weeds growing with crop plants use light, water and nutrients that should be available to the crop plants, and therefore may reduce crop yields. The extent of yield reduction varies depending on climatic and edaphic conditions, but it is primarily a function of the relative competitiveness of the crop and weed plants which, in turn, is affected by a number of factors. The size of the initial photosynthetic area is important, as are the rate of production of leaf area and the net assimilation rate. The rate of production, extent and distribution of the root system and the rate of uptake of water and nutrients also affect the outcome of competition. Thus, the time of emergence of the crop and weed plants and their efficiency in using available resources will determine their success. The density of the populations and the time of weed removal must also be considered (7,20,26,27,30,36,41).

In intraspecific competition studies with chickweed, densities of 1, 2, 4, 6 and 8 plants per pot all resulted in about the same amount of above-ground dry matter per pot. Root dry matter increased up to a density of four plants per pot (27).

Although there are few published reports of competition studies with chickweed, it is reported to reduce the yield of some crops. Chickweed reduced the weight of tops and

roots of container-grown carrots (7), but it had little effect on container-grown kale (50). In a field experiment, the yield of sugar beet was reduced by 50% where chickweed was an important weed (41). The yield of fall-planted cabbage in Scotland was reduced if weeds were not removed before the period of rapid crop and weed growth in the spring (26). Chickweed was the main weed problem there because of its winter annual habit and its ability to grow rapidly in the early spring, shading the cabbage.

In greenhouse pot experiments, the dry weight production of ryegrass (20) and barley (27) was reduced by competition with chickweed. The loss was increased in both cases with increasing density of the weed. Increasing barley density, while holding chickweed numbers constant, increased the competitive ability of the crop (27). A field experiment in Sweden (19) showed a 40% reduction in barley yield with a density of 135 chickweed plants per m^2, on untreated plots as compared with those treated with 2.0 kg/ha MCPA (see 'Materials and Methods' Table III.1 for chemical name).

F. Control

A variety of herbicides is available for the control of chickweed in a wide range of crops. The following chemicals are recommended for use in Alberta (1). In cereals, linuron + MCPA, cyanazine + MCPA, metribuzin or mecoprop can be used to control chickweed (see 'Materials and Methods' for chemical names). Trifluralin (α,α,α-trifluoro-2,6-dinitro-

N,*N*-dipropyl-*p*-toluidine) is recommended for rapeseed. In flax, cyanazine + MCPA, linuron + MCPA, trifluralin or EPTC (*S*-ethyl dipropylthiocarbamate) can be used for chickweed control.

G. Uses of Chickweed

Chickweed may be a serious weed, but through the years it has had many uses. In the recent past, farmers along the Rhine in Europe carefully transplanted chickweed into their vineyards to hold the soil and to produce a grape crop of superior quality and yield. Some Scandinavian farmers still encourage chickweed in their orchards in the belief that it will bring good fruiting and high yields (21).

Chickweed was a favorite of the herbalists in days gone by. Chopped and boiled greens were used in a poultice to heal boils, inflammation, external abscesses and skin cancers (11,16,42). Chickweed juice was prescribed for scurvy and inflammation of the eyes and it was reputed to heal cancers (16).

On the dinner table, chickweed is a fine potherb. The young growing tips can be used as salad greens or as a cooked vegetable. The following recipe is provided by Szczawinski and Turner (42).

Oriental-Style Chickweed

15 ml peanut oil

1 clove garlic, minced

750 ml chickweed leaves, washed and chopped

10 ml cornstarch

15 ml soy sauce

250 ml cold water

2 ml grated ginger

125 ml chow mein noodles

Heat oil in a frying pan or wok. Add garlic and stir-fry until well browned. Add chickweed leaves and stir constantly for 3 minutes. Mix cornstarch and soy sauce in water and pour over chickweed. Add ginger. Stir until the liquid thickens, being careful not to overcook. Add noodles. Stir and serve immediately.

For those who would rather not eat it, chickweed can be used as a vegetable dye. Personal experience has shown that chickweed will produce a pale green dye on alum-mordanted wool.

III. Materials and Methods

A. Seed Germination

Experiments were carried out to determine the effect of various treatments on germination of chickweed seed. Four lots of seed were used in these trials. They were stored dry at room temperature.

Lot No.	Date Collected	Location
78	July-Aug 1978	Ellerslie
79A	July 12,1979	greenhouse
79B	July 31,1979	NE23-57-25-W4
79C	Aug 14,1979	NW15-57-24-W4

The germination procedure described here was used in all seed germination experiments except as noted. Four lots of 50 seeds each were counted for each treatment. They were placed on two layers of moist filter paper in a closed petri dish and put in a dark incubator at 15°C. The dishes were watered as required with distilled water and germination was checked periodically. Seeds were considered to have germinated when the radicle protruded 1 mm. Trials were terminated after 10 days.

Monthly Germination Tests

Seed lots 79A, 79B, and 79C were used in this experiment. Seeds were first tested for germination 3 months after collection, and then each month for 8 months. Three

treatments were applied to each seed lot.

1. Dry seeds were placed on filter paper moistened with distilled water.
2. Dry seeds were placed on filter paper moistened with 0.2% potassium nitrate.
3. Seeds were covered with 0.1% gibberellic acid for 24 hours. They were then placed on filter paper moistened with distilled water.

The germination procedure described above was followed.

Plants were grown in the greenhouse from seed lots 79A, 79B and 79C, and seed was collected to determine if dormancy characteristics were inherited. Germination was tested immediately after collection of the seed and 6 weeks later. The treatments applied to these seeds were as described above.

Cold Storage of Seed

Seed of lot 79C, in counted lots of 50 seeds each, was placed in small nylon bags that were wetted and buried in a tray of moist vermiculite, or in paper envelopes that were stored dry. Seed for both treatments was kept in a coldroom at 4°C. After 1, 2, 4, 6 and 8 months, four lots of seeds were removed from each treatment and tested for germination.

Temperature for Germination

Seed of lot 78 that had been stored for 10 months was used for this experiment. Seeds were placed in the dark at

3°C, 10°C, 15°C, 20°C or 25°C for germination. At each temperature, two treatments were applied. Seed was germinated in distilled water or it was treated with gibberellic acid as described in the first section, to overcome dormancy. Seeds of lot 79B were germinated at 8°C, 23°C and 30°C with treatments as describedabove.

Effect of Soil Applied Potassium Nitrate

Fifty gram samples of soil that contained 6 ppm nitrate were placed in individual petri dishes and 15 ml of either water or potassium nitrate solution was added. Enough potassium nitrate was added to increase the soil nitrate concentration by 60, 300 or 1200 ppm nitrate. Petri dishes were closed and left for one week to allow distribution of potassium nitrate through the soil. Seed of lot 79B was placed on the soil surface and the dishes were closed and left to germinate at 15°C.

Depth of Seeding

Seed of lot 79A was covered with 0.1% gibberellic acid for 24 hours to break dormancy. It was allowed to dry and then seeded into greenhouse potting mix (soil, peat and sand, 3:2:1) in 12.5-cm plastic pots. Seeds were placed on the soil surface and at depths of 0.5, 1, 2, 3 and 5 cm. The pots were placed in a greenhouse at 18°C. Emergence was observed periodically for 1 month after seeding.

B. Growth and Development

Experiments were carried out in the greenhouse and in the field, at Ellerslie, to observe growth and development of chickweed plants.

Chickweed was seeded in greenhouse potting mix (see page 18) in 12.5-cm plastic pots. The plants were thinned to one plant per pot when they had two pairs of true leaves. Four plants were observed daily and photographs were taken weekly until seed production was well underway. Several unopened flower buds were tagged and daily observations were made of their development.

Chickweed was seeded in the field on October 23, 1979, to ensure germination the following spring. Emergence was recorded and the plants were observed and photographed weekly until the end of July. Each week the following measurements were taken on four plants: length of the main stem, length of the third internode from the apex, and length and width of the leaf above that internode. These leaves and internodes represented the youngest fully expanded parts of the plant. When the plants began to flower, the position of leaves and internodes relative to the first flower was recorded. Flowers produced on the main stem and each of the first two branches were counted. Monthly observations were made through the fall to observe late season growth and cold tolerance.

An experiment was conducted to determine the length of time from flowering to production of viable seeds. Chickweed

was grown in shallow 20-cm plastic pots in the greenhouse. Approximately ninety flowers were tagged on the first day of opening, and capsules were collected 7, 8, 9, 10 and 11 days after tagging. Of sixteen capsules collected each day, eight were placed in a paper envelope and stored for later germination. The others were measured and observations of seed development were made. The seeds in each capsule were counted and they were pooled for a germination test. Seeds were put on filter paper in a petri dish with 3.5 ml of 0.1% gibberellic acid. The petri dishes were placed in a dark incubator at 15°C. Germination was checked periodically and distilled water was supplied to keep the seeds moist. The stored seeds were tested for germination 7 weeks after collection. The seeds in each capsule were counted and they were pooled for germination tests. Seeds were covered with 0.1% gibberellic acid for 24 hours, then placed in petri dishes on filter paper moistened with distilled water. They were germinated under the same conditions as the previous lot.

A few seedlings emerged with three cotyledonary leaves rather than the normal two. Three of these plants were transplanted and observed in the greenhouse.

Chickweed seedlings were set out in the fall to determine if they were capable of survival as winter annuals. Seed was soaked in 0.1% gibberellic acid for 24 hours immediately before seeding, to overcome dormancy. Seeding was done on three dates: August 30, September 19 and

October 3, 1979. On each date, ten seeds were planted in each of fifteen peat pots. The pots were stored outdoors until all plants had emerged, then they were thinned to one plant per pot. On October 23, 1979, the pots were set into the soil in the field for the winter. They were observed in April, 1980 for survival.

C. Light

An experiment was carried out to determine the effect of light intensity on growth of chickweed. Seed was soaked 24 hours in 0.1% gibberellic acid, to break dormancy. It was allowed to dry before seeding into UC mix (sand and peat, 1:1 + potassium nitrate, potassium sulphate, superphosphate, calcium carbonate, magnesium carbonate, bone) in 170-ml styrofoam cups. The cups were placed in a growth cabinet at 17°C with a 16-hour photoperiod. Three days after emergence, the chickweed was thinned to one plant per pot and put under four different light intensities that were created by the placement of pots within the growth cabinet (Figure III.1). Pots at the lowest light intensity were placed under a bench. The light was primarily from one direction so pots were placed only two deep to minimize the difference in light intensity received by plants at the front and back of this group. The next light level was created by placing pots at the bottom of the growth cabinet under a frame covered with four layers of cheesecloth. The two higher light intensities were achieved by putting the plants on benches

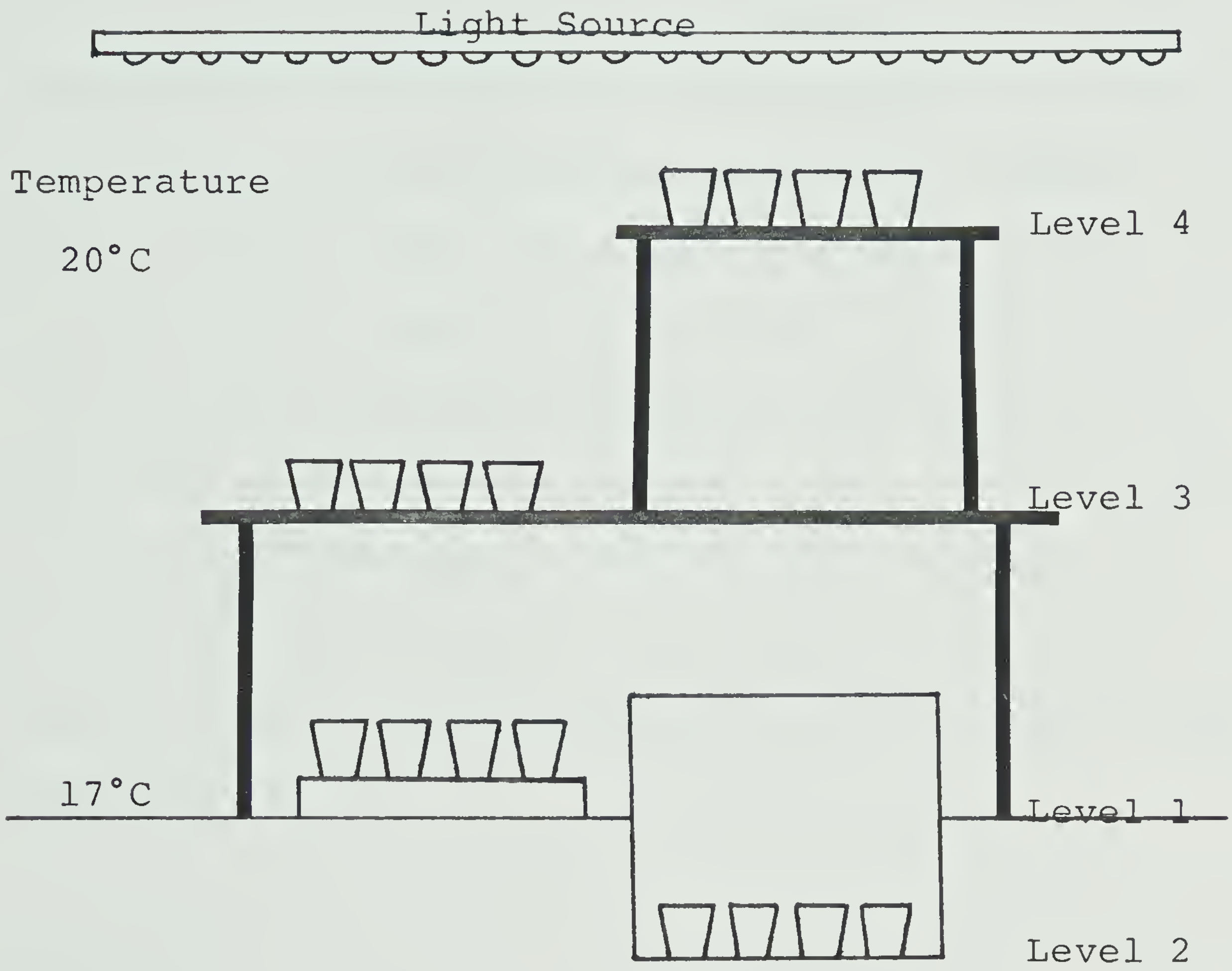

Figure III.1 Experimental Setup for Light Experiment

closer to the light source. A slightly higher temperature was experienced by the plants closest to the light source.

The light provided was a mixture of incandescent and cool-white fluorescent. Light intensities were measured as quantum flux in the 400 to 700 nm range, using a Li-Cor LI-190S Quantum Sensor.

Treatments were replicated four times and pots were rotated twice weekly within replicates at each light level. Four plants were harvested each week beginning one month after emergence of the seedlings. Photographs were taken and shoot dry weights were determined as were the length of the main stem, length of the third internode from the apex and length and width of the leaf above that internode.

Field observations were made on plants growing in 17 different locations. In each location, the light intensity was measured and the type of habitat was recorded. The length and width of a leaf in the vegetative portion of the plant and a leaf at the node where the first flower arose, were measured.

D. Temperature

An experiment was carried out to determine the effect of temperature on growth of chickweed. Chickweed was seeded into greenhouse potting mix (see page 18) in 170-ml styrofoam cups and placed in the greenhouse. Within 5 days of emergence, the seedlings were thinned to one per pot and transferred to temperature-controlled incubators. Two

identical incubators were used. The photoperiod was set at 16 hours and light intensity at shelf level was 140 E/m^2/sec.

Every week, beginning about 2 weeks after the plants emerged, four plants were randomly selected for harvest from each treatment. Shoot dry weight, length of the main stem, length of the third internode from the apex of the main stem and length and width of the leaf above that internode were recorded. A note was made of plants that were flowering at the time they were harvested.

Chickweed plants were grown at constant temperatures of 8°C, 16°C, 23°C and 30°C, and under an alternating temperature regime of 30°C in the light period and 20°C in the dark. The 8°C and 30°C treatments were run simultaneously, as were the 16°C and 23°C treatments. Plants grown at 30°/20°C were started when those grown at 30°C died, about 25 days after the experiment began, and they were observed for only 5 weeks rather than 8 weeks as the other treatments were.

E. Soil Water Content

An experiment was carried out to observe the response of chickweed to low soil water conditions. Black loam soil was passed through a 6 mm mesh sieve and 800 g soil was placed in 12.5-cm plastic pots. Field capacity and permanent wilting point of the soil were determined by the standard pressure plate method. The total weight of the pot, soil and

water at field capacity was calculated and this weight was used to determine field capacity when watering the pots. Chickweed was seeded and the pots were then watered up to field capacity and placed in the greenhouse. After emergence, the seedlings were thinned to one per pot. The pots were watered to field capacity regularly for 2 weeks, after which four treatments were imposed.

1. Pots were watered to field capacity daily.
2. Pots were allowed to dry until the plants were at the point of wilting and were then watered to field capacity. The leaves were limp to the touch, but were not obviously wilted.
3. Pots were allowed to dry until the leaves were wilted and were then watered to field capacity.
4. Pots were watered to field capacity when the plants had been wilted for 2 days.

Timing of the watering was determined by the appearance of the plants. The time between waterings varied slightly depending on weather conditions as they affected the rate of evapotranspiration from the pots. Plants went through the watering and drying cycle repeatedly during the course of the experiment. The weight to which the pots were watered was adjusted upward at each harvest according to the average increase in fresh weight of plants in each treatment.

The experiment was a randomized complete block design with four replicates. Pots were rotated within the replicates twice weekly. Harvests were taken 27, 38 and

48 days after emergence. Shoot dry weight, length of the main stem, internode length and leaf length and width were measured. At the first and second harvests, the leaf and internode measured were in the vegetative portion of the plant, fourth from the apex of the main stem. At the final harvest, a leaf at the first flower and the internode immediately above it were measured.

F. Competition

A greenhouse experiment was carried out to observe the effect of intraspecific competition on the growth of chickweed. In three additional experiments, the effects of chickweed density and time of emergence on barley growth were investigated.

Intraspecific Competition

Chickweed seed was soaked for 24 hours in 0.1% gibberellic acid to break dormancy. It was dried before seeding into UC mix (see page 21) in 12.5-cm plastic pots which were placed in a greenhouse at 18°C to 25°C. Two days after emergence, seedlings were thinned to give 1, 2, 5, 10, 25, 50 or 100 plants per pot. Opaque cardboard collars were placed around the plants to support them and to force them to grow upright. The collars were built up in segments 10 cm high as the plants grew. Plants were harvested from four pots at each plant density 11, 25 and 39 days after emergence. At each harvest, one plant in each pot was

randomly selected for the following measurements:

1. Length of the main stem
2. Length and width of leaves
    a. first harvest - first true leaf
    b. second harvest - first and fourth leaves
    c. third harvest
        1) leaf below first flower
        2) leaf at first flower.
        3) leaf at third flower

Shoot dry weight per pot was determined and the initial density was used to calculate the dry weight per plant. Some plants may have died between thinning and harvest, but there was no evidence that this was the case. Pots were rotated twice weekly within replicates for each harvest date.

Competition with Barley

Chickweed seed was soaked in 0.1% gibberellic acid for 24 hours and dried before seeding into 12.5-cm plastic pots. The pots were placed in a greenhouse at 18°C to 25°C. Seedlings were thinned to the desired stand 5 to 10 days after emergence. Galt barley was seeded in each pot and thinned to four plants per pot 2 to 3 days after it emerged. Timing of the emergence of chickweed relative to the barley is described below. Barley shoot dry weight, height, leaf stage and the average number of tillers per plant in each pot were recorded at each harvest as were chickweed shoot dry weight and height.

Three experiments were carried out. In the first experiment, the effect of chickweed density on barley growth was studied, while the others were concerned with the effect of the time of emergence of chickweed on barley growth.

In the first experiment, the potting medium was greenhouse potting mix (see page 18). Chickweed emerged 1 day after the barley and was thinned to 1, 2, 5, 10, 25, 50 and 100 plants per pot. After thinning, the plants were enclosed in a cylinder of fibreglass screening 30 cm tall to force the chickweed to grow upright as it would in a barley field. The pots were fertilized with 15-30-15 nine days after the barley emerged. Plants of both species were harvested from four pots for each density 15, 25 and 35 days after barley emergence.

Two experiments, with two different chickweed densities, were done to study the effect of the time of emergence of chickweed on barley growth. In the first one, chickweed was seeded into UC mix (see page 21) so that it emerged 15, 8 or 5 days before the barley, with the barley, or 4, 7 or 14 days after the barley. Chickweed was thinned to 35 plants per pot. The plants were supported with cardboard collars as described in the section 'Intraspecific Competition'. Plants were fertilized with 20-0-25 nine days after barley emergence and with 15-15-30 twenty-three days after emergence. Harvests were taken 16, 30 and 45 days after emergence of the barley.

In the second experiment chickweed was seeded into greenhouse potting mix (see page 18) to emerge 15, 9, 6 or 2 days before the barley, or 2, 5 or 12 days after the barley. Chickweed was thinned to 15 plants per pot. The plants were supported with fibreglass screening as described above. Plants were fertilized with 15-15-30 eight days after barley emergence. Harvests were taken 13, 24 and 34 days after emergence of the barley.

Treatments in all three experiments were repeated four times and pots were rotated twice weekly within replicates for each harvest date.

G. Control

The efficacy of chickweed control with several registered and experimental herbicide treatments was studied in a greenhouse experiment and four field trials. Herbicides that were used in these experiments are listed in Table III.1.

Greenhouse Experiment

Chickweed was seeded in 12.5-cm plastic pots that were placed in a growth room at 20°C. Four days after emergence, seedlings were thinned to eight per pot. Pots were sorted into replicates according to the size and vigor of the plants at the time of spraying. The experiment was a randomized complete block design with four replicates.

Herbicides were applied with a mechanical pot sprayer in 110 L/ha of water at 275 kPa using a TeeJet 8001E nozzle.

Table III.1 Herbicides Used for Control of Chickweed in Greenhouse and Field Trials

Common Name	Chemical Name	Formulation[4]
A5633[1] (bromophenoxim + atrazine)	3,5-dibromo-4-hydroxybenzaldehyde-O-(2′,4′-dinitrophenyl)-oximine 2-chloro-4-(ethylamino)-6-isopropylamino-*s*-triazine	FL
Benazolin amine[1]	4-chloro-2-oxobenzothiazolin-3-ylacetic acid	S
Bromoxynil[1]	3,5-dibromo--4-hydroxybenzonitrile (ester of N-octanoic acid>	EC
Cyanazine + MCPA-K[3]	2-[[4-chloro-6-(ethylamino) *s*-triazin-2-yl]amino]-2-methylpropionitrile	FL
Dicamba +MCPA-K[1 3]	3,6-dichloro-*o*-anisic acid (dimethyl amine)	S
DPX 4189[1]	2-chloro-N-[(4-methoxy-6-methyl-1,3,5-triazin-2-yl) aminocarbonyl]benzenesulfonamide	1979 WP 1980 DF
Linuron[2]	3-(3,4-dichlorophenyl)-1-methoxy-1-methylurea	WP
MCPA amine[1]	[(4-chloro-*o*-tolyl)oxy]-acetic acid	S
Mecoprop	2-[(4-chloro-*o*-tolyl)oxy]-propionic acid (iso-octyl ester)	S
Metribuzin	4-amino-6-*tert*-butyl-3(methylthio)-*as*-triazin-5(4*H*)-one	FL
Propanil +MCPA ester[1 3]	3′,4′-dichloropropionanilide	EC

[1] Not registered in Canada for chickweed control.
[2] Tank mix with MCPA registered for chickweed control.
[3] Commercial mix.
[4] FL=flowable, DF=dry flowable, WP=wettable powder, EC=emulsifiable concentrate, S=solution

Applications were made when the chickweed had four pairs of true leaves or when it had seven to eight pairs of leaves. The plants were observed every 2 to 4 days and fresh weights were determined 28 days after spraying.

Field Experiments

Field experiments were set out in 1979 and 1980 on farmers' fields in the Bon Accord area. The soils were loam to silt loam with 10 to 13% organic matter. The experiment was done in two locations each year. Plots 2.9 x 5.5 m were marked in a randomized complete block design with four replicates. Herbicides were applied with a bicycle-type plot sprayer in 110 L/ha of water at 275 kPa using TeeJet 8001 nozzles. At harvest, a sample was taken from each plot for determination of crop yield and dry weight of chickweed, except in experiment 80B where new growth of chickweed made results unreliable. The sample size was 0.84 m^2 in 1979 and 1.67 m^2 in 1980. Chickweed control was scored on a scale of 0 to 9. Spray dates and growth stages are shown below.

Experiment	Spray Date	Leaf Stage		Harvest Date
		Crop	Weed	
79A	June 22	4-5	2-4 pr	August 28
79A (lin/MCPA)	July 4	7	3-6 pr	August 28
79B	July 6	5-6	5-6 pr	August 28
80A	June 20	3-4	2-3 pr	September 3
80B	June 14	3-5	1-2 pr	September 3

IV. Results

A. Seed Germination

Monthly Germination Tests

Germination of untreated seed varied from month to month (Figure IV.1) Seed of lot 79A germinated considerably better than that of the other seed lots. This seed was collected from plants that were grown in the greenhouse and the pods were oven dried before threshing. The other two seed lots were collected in the field and air dried. The difference in origin and treatment of the seed may account for the difference in germination. Dormancy also may have been affected by the conditions prevailing while the seed was maturing on the plant. This possibility was not pursued so no conclusions can be drawn.

Seeds that were treated with gibberellic acid consistently germinated near 100%. Consistently high germination was observed in seeds of lots 79A and 79B when they were treated with potassium nitrate, however, germination of potassium nitrate treated seeds of lot 79C was variable from month to month. Gibberellic acid has been reported to overcome dormancy in some species (45). Corns (10) reported that presoaking in 0.05% or 0.1% gibberellic acid did not increase chickweed germination, however, it was effective on all three seed lots tested here. Potassium nitrate also has been used to break dormancy in chickweed

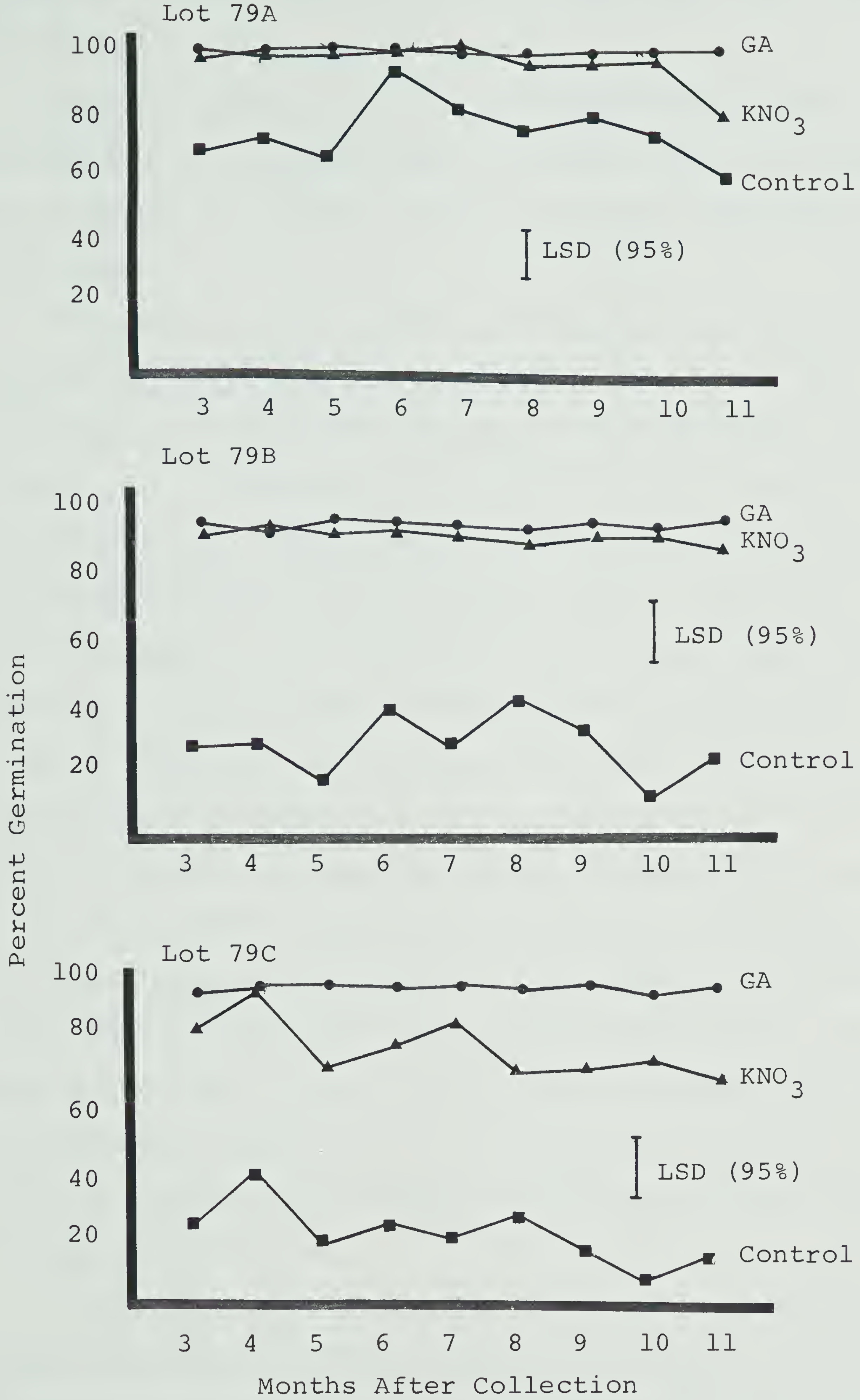

Figure IV.1 Germination of Chickweed Seed from Three Lots

seed (2). It was effective on all three seed lots, with some variability in the case of lot 79C.

Several authors (10, 15, 34) have reported that germination of chickweed seed increased after dry storage for 6 months to 3 years. No such trend was observed in this experiment.

Progeny of seed lots 79A, 79B and 79C was tested to determine if dormancy characteristics were inherited. Germination of untreated seed was less than 10% in all cases (Table IV.1). Treatment with gibberellic acid resulted in germination near 100%. Potassium nitrate treated seeds of 79A progeny germinated considerably better than those of 79B and 79C progeny. The second generation seed showed an increase in germination of untreated and potassium nitrate treated seed after dry storage for 6 weeks. The increase in germination of 6 week old seed, as compared with fresh seed, when treated with potassium nitrate, leads to the hypothesis that fully dormant seeds are not sensitive to potassium nitrate. These results contrast with those of the previous experiment and indicate that dormancy was probably lost during the three months in which the first seed lots were stored before germination tests were begun. Over time, the state of dormancy may change so that seeds become sensitive to potassium nitrate.

Untreated seeds of lot 79A germinated considerably better than those of lots 79B and 79C, however, progeny of 79A did not germinate as well as that of the other two seed

Table IV.1 Percent Germination of Progeny of Seed Lots 79A, 79B and 79C

Parental Population	Treatment	Weeks after Collection 1	6
79A	Control	7.0 ± 1.3[1]	14.5 ± 3.0[1]
	GA	100.0 ± 0	100.0 ± 0
	KNO_3	74.0 ± 5.3	90.0 ± 0.8
79B	Control	9.5 ± 2.1	34.0 ± 2.4
	GA	100.0 ± 0	99.5 ± 0.5
	KNO_3	39.5 ± 7.3	64.5 ± 4.6
79C	Control	6.0 ± 2.2	22.0 ± 4.2
	GA	99.0 ± 0.6	99.5 ± 0.5
	KNO_3	37.0 ± 3.1	68.5 ± 4.6

[1] Standard error based on four observations.

lots. In the first seed lots tested (Figure IV.1), potassium nitrate treated seed of lot 79C did not germinate as well as that of the other seed lots. In the second generation (Table IV.1), nitrate-treated 79C seed germinated as well as 79B, but neither germinated as well as 79A. It appears from these observations that dormancy characteristics in chickweed seed are not inherited, however, further study is required to draw firm conclusions.

Cold Storage of Seed

Seeds of lot 79C showed a slow increase inpercentage germination over time when stored dry at 4°C (Figure IV.2). Seed that was stored moist at 4°C lost its dormancy quickly. Within one month of imposing the storage conditions, germination of this seed had increased from 25% to 88%.

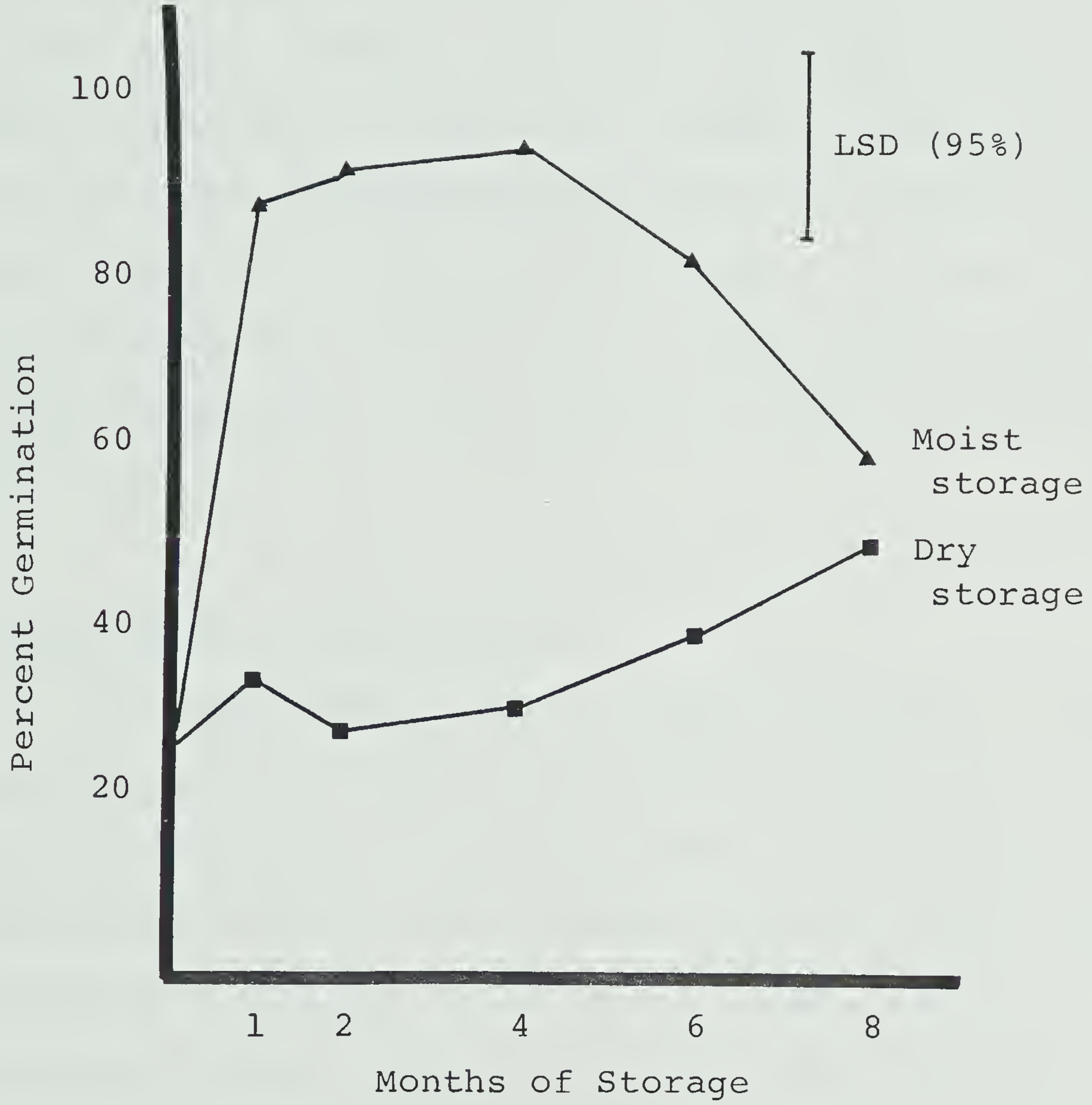

Figure IV.2 Germination of Cold-Stored Chickweed Seeds

Germination remained high for four months after which the seed began to lose viability. The viability of chickweed seeds buried in the field has been shown to decline within 6 months of burial and to be lost entirely after 30 months (15). In other studies, chickweed seed was reported to retain viability for 10 years (47) and 30 years (12). In the former study, however, only 3% of the seeds buried at 20 cm were viable after 6 years. Darlington's report did not indicate the percentage germination, but stated that one or more seeds were viable after 30 years. It seems reasonable to conclude that most of the chickweed seed buried in the ploughed horizon in the field will remain viable for only a few years.

Temperature for Germination

Chickweed seed of lot 78 germinated over a wide range of temperatures (Table IV.2). Seeds treated with gibberellic acid were assumed to be non-dormant. At intermediate temperatures (10 to 20°C), germination of these seeds was high but at 3°C and at 25°C it was poor. Seeds at 10°C required 5 days longer to reach maximum percentage germination than did those at higher temperatures. The few seeds that germinated at 3°C did so 26 to 31 days after they were moistened. Germination of untreated seeds was less than that of gibberellic acid treated seeds but both showed the same pattern in response to temperature.

Table IV.2 Effect of Temperature on Percent Germination of Chickweed Seed of Lot 78

Temperature	Treatment	Germination (%)	Time to Peak Germination
3°C	Control	0	
	GA	2 ± 0.5	1 month
10°C	Control	13 ± 3.1	11-12 days
	GA	77 ± 2.5	11-12 days
15°C	Control	25 ± 2.4	6-7 days
	GA	78 ± 3.8	6-7 days
20°C	Control	30 ± 4.6	6-7 days
	GA	78 ± 4.2	6-7 days
25°C	Control	2 ± 0.8	6-7 days
	GA	6 ± 1.8	6-7 days

[1]Standard error based on four observations.

Seeds of lot 79B were germinated at 8°C, 23°C and 30°C. More than 95% of the seeds that were treated with gibberellic acid germinated at 8°C and 23°C, but only 16% germinated at 30°C. Seeds held at 8°C took about one week longer to reach maximum germination than did those held at 23°C. This experiment did not include a complete range of temperatures but the results support those reported for seed lot 78.

The optimum temperature for germination appears to lie in the range of 15 to 23°C. At 10°C, germination was high but slow. Germination was inhibited at 25°C and 3°C. The results obtained are similar to those reported by Roberts and Lockett (34). They reported the optimum constant temperature for germination of chickweed seed to be in the

range of 12 to 20°C. Germination was reduced at 25°C and very few seeds germinated at 30°C.

Effect of Soil Applied Potassium Nitrate

Potassium nitrate was applied at three rates, to a soil low in nitrogen. Germination increased with nitrate applications (Table IV.3). A high percentage of the seeds germinated when 1200 ppm of potassium nitrate was added to the soil. This rate was equivalent to a field application of 250 kg/ha of nitrogen. It has been reported that germination of fresh chickweed seed is stimulated when soil rather than filter paper is used as a substrate (2). Soil nitrate level was not reported in that experiment but it may provide a partial explanation for the increase in germination observed on a soil substrate.

Depth of Seeding

Chickweed was seeded at depths ranging from the soil surface down to 5 cm (Table IV.4). Emergence was best from the 0.5 and 1.0 cm depths, while deeper seeding reduced emergence. No plants emerged from 5 cm; however, when the pots were emptied some germinated seeds were observed at that depth. Chickweed that was seeded at 2 and 3 cm emerged about 2 days later than that which was seeded more shallowly. Seeds placed on the surface of the soil did not germinate as well as those seeded shallowly. This was likely due to alternate wetting and drying experienced on the soil

Table IV.3 Effect of Soil Applied Potassium Nitrate on Percent Germination of Chickweed Seed of Lot 79B

Potassium Nitrate Applied		Germination %
ppm NO_3	kg/ha N in top 10 cm	
0	0	40 ± 5.4[1]
60	12	46 ± 10.6
300	60	72 ± 6.0
1200	250	94 ± 2.6

[1]Standard error based on four observations.

Table IV.4 Effect of Depth of Seeding on Percent Emergence of Chickweed Seedlings from Seed Lot 79A

Depth cm	Emergence %
surface	66 ± 3.1[1]
0.5	89 ± 5.8[2]
1.0	89 ± 4.4[1]
2.0	48 ± 8.3
3.0	13 ± 6.4
5.0	0 ± 0

[1]Standard error based on four observations.
[2]Standard error based on three observations.

surface. Buried seeds had a more constant moisture supply and thus germination was more complete.

Duer (14) reported that chickweed seedlings emerged best from depths of 0.6 and 1.2 cm and emergence decreased as depth of seeding increased. In his experiment, a few seedlings emerged from 5 cm but none emerged from 7.8 cm.

B. Growth and Development

The growth and development of chickweed plants in the greenhouse is summarized in Table IV.5. The plants were initially erect but became prostrate as they grew. They grew rapidly and branched profusely during the vegetative phase. Generally, at least one lateral branch arose from each node on the main stem and much secondary branching occurred. Flowering was continual and occurred over a long period as progressively younger branches began to flower. In the flowering phase, one flower arose from each node and branching proceeded as illustrated in Figure IV.3.

Leaves in the vegetative phase were ovate and petiolate. In the flowering phase, they were narrower and sessile. The largest leaves were found at or near the node bearing the first flower, on each branch. New leaves produced were progressively larger until flowering began while leaves produced later remained smaller. The longest internodes were also found in the early flowering phase of the plant.

Table IV.5 Summary of Growth and Development of Chickweed in the Greenhouse

Days After Emergence	
4	First pair of true leaves on main stem.
8	Second pair of leaves.
10	Third pair of leaves. Branches developing in axils of the cotyledonary leaves.
15	Fourth pair of leaves. Branches developing in axils of first true leaves. Second branch developing in axil of each cotyledonary leaf. Plants are taking on a prostrate habit.
17	Fifth pair of leaves. Branches growing in axils of second pair of leaves and from lowest leaf axils on oldest branches.
24	Six to seven pairs of leaves on main stem. Flowers open on main stem. Branching continues.
26	Two or three flowers or buds on main stem. One flower bud on each of the lowest branches.
29-32	Fruit set from first flowers.
44	Some of the oldest leaves are becoming chlorotic.

Figure IV.3 Flowering Branch of Chickweed Showing Attachment of Flowers and Type of Branching

Growth and development of chickweed plants in the field was similar to that of plants grown in the greenhouse. The length of time from emergence to flowering was about 40 days. This was slightly longer than for the greenhouse plants; however, in the field more leaf pairs were produced before flowering began. Figure IV.4 illustrates plants growing in the field. The first flowers were produced on the main stem, followed shortly by flowers produced on the oldest branches. Progressively younger branches continued to come into flower over a period of four to five weeks. During the latter half of the flowering period, the leaves and stems began to yellow. By the third week of July, about 80 days after emergence, flowering ceased. Each of the three oldest stems produced eight to eleven flowers. Fewer flowers may have been produced on younger stems but this was not confirmed. The leaves were senescent and stems were yellow and broke easily at the nodes. At the same time, there were some new green branches near the base of the plants. This new growth was in flower by the beginning of September. These flowering stems developed more slowly than those produced in July, likely due to lower temperatures in the fall. The plants appeared much the same in mid-October as they had in September. The final observation was made in late November. During the latter half of October and in November, freezing temperatures occurred regularly with overnight lows commonly in the -1 to -7°C range. Stems appeared dry and brown. They were still supporting green

A

B

C

D

E

F

Figure IV.4 Growth of Chickweed Plants in the Field

Days after Emergence: A. 20 days B. 27 days C. 42 days
D. 54 days E. 62 days F. 80 days

leaves and flower buds on the tips of many branches but most of the leaves were dead.

The largest leaves on field-grown plants were found in the early flowering portion of the plant as shown in Table IV.6. The longest internodes were also found in this portion of the plant (Table IV.7) and thus the flowering stems were much longer than the rest of the plant. The stems in the flowering portion of the plant appeared to be thicker than those in the vegetative portion.

The shape of leaves in the vegetative and flowering portions of the plant was compared by means of a leaf ratio that was calculated by dividing the length of the leaf by its width. Leaves in the vegetative phase of the plant were broader than those in the flowering phase. The leaf ratio for vegetative stage leaves ranged from 1.1 to 1.5, while in the flowering phase the leaf ratio was 1.6 to 2.3. These results are similar to those presented by Komatsu (24) for *Stellaria neglecta*, however, she described a 'fructification' stage which could not be differentiated from the flowering stage in the data collected here. Additional data on leaf ratios were collected in experiments dealing with the effects of light, temperature and competition and are reported with those experiments. Leaf ratio was not affected by light or competition; however, at high temperatures very narrow leaves were produced.

Chickweed flowers remain open only one day and most flowers are fertilized and produce capsules. Capsule and

Table IV.6 Length of Leaves at Various Positions on Field Grown Chickweed

Position of Leaf	Date Observed	Leaf Length (cm)
Vegetative	May 29	1.2 ± 0.02[1]
Vegetative	June 6	1.5 ± 0.11
Node below first flower	June 13	2.3 ± 0.10
At first flower	July 3	3.6 ± 0.21
At third flower	July 3	2.7 ± 0.23
Third from top (about seventh flower)	July 21	1.0 ± 0.07[2]

[1]Standard error based on four observations.
[2]Standard error based on three observations.

Table IV.7 Length of Internodes at Various Positions on Field Grown Chickweed

Position of Internode	Date Observed	Internode Length (cm)
Vegetative	May 29	1.3 ± 0.06[1]
Vegetative	June 6	1.5 ± 0.11
Below first flower	June 25	3.5 ± 0.51
Above first flower	July 3	6.5 ± 0.68
Above second flower	July 3	9.3 ± 0.10
Fourth from top (about sixth flower)	July 21	6.0 ± 0.50[2]

[1]Standard error based on four observations.
[2]Standard error based on three observations.

seed development takes place rapidly. A description of capsules and seeds collected seven to 11 days after flowering is provided in Table IV.8. The capsules became translucent and dry as they aged. Once they reached this stage, they split readily when touched and could likely be opened, in the field, by wind or animal activity. By the time the pods split readily, most of the seeds were brown and firm.

Seeds collected 7 to 11 days after flowering were tested for viability. Dormancy was overcome with gibberellic acid and all seeds germinated well (Table IV.9). Seven day seeds were still soft and moist and under field conditions they may not survive long enough to germinate. The radicle that emerged from these seeds was spindly and the seedlings would not likely emerge.

Some chickweed seedlings emerged with three cotyledonary leaves and three such plants were observed during their subsequent growth. Branches produced on all three plants had two leaves at each node, and each plant reverted to the normal two leaves per node, on the main stem, before flowering began. In one case, the main stem had whorls of three leaves at each node until just before it flowered. The leaf pair before the first flower was made up of one normal leaf and one which was cupped and had the appearance of two leaves joined at one margin. A second plant had two leaves per node beginning with the first true leaves. The third plant was intermediate between the other

Table IV.8 Development of Chickweed Seed Pods

Days After Flowering	Length of Pod (cm)	Description of Pod and Seeds
7	3-5	Pods exserted from calyx, green. Stigma attached. Pods do not split readily. Seeds soft, moist, white, 1 mm diameter.
8	4-6	Pods similar to day 7. Seeds firmer, some are beginning to turn brown.
9	4-6	Pods green, becoming translucent. Pods split readily when squeezed. Stigma still attached. Some seeds white, but most are light to medium brown.
10	4-6	Pods translucent. Many pods are open, those that are not split readily when squeezed. Stigmas still attached to closed pods. Seeds medium brown, 1 mm diameter.
11	4-6	Pods and seeds similar to day 10. Most pods are open.

Table IV.9 Germination of Chickweed Seeds Collected Seven to Eleven Days After Flowering

Days After Flowering to Seed Collection	Germination (%)
7	89
8	87
9	95
10	95
11	98

two. All leaves on the latter two plants were normal.

Chickweed seedlings set out in the field in the fall did not survive the winter. Observations of mature plants in my yard, in Edmonton, indicated that they are more likely to survive the winter than are seedlings. Some of these plants still had green leaves on the tips of a few branches when the snow melted in late March. They were similar in appearance to the plants observed in the field in late fall. By mid-April, however, the green portions were all dead. It is quite likely that the plants were unable to withstand the daily temperature fluctuations in the spring without an insulating snow cover. Given ideal conditions, chickweed could possibly overwinter in northern Alberta, however, this is not likely to occur except in isolated instances.

C. Light

Chickweed was grown under four light intensities:

Level 1	10-24 $\mu E/m^2/sec$
Level 2	45-60 $\mu E/m^2/sec$
Level 3	190-240 $\mu E/m^2/sec$
Level 4	385-430 $\mu E/m^2/sec$

Dry weight increased with light intensity during the course of this experiment (Figure IV.5). The rate of growth of plants at 400 $\mu E/m^2/sec$ began to decrease 7 weeks after emergence, and at the final harvest the dry weight of plants grown at 200 $\mu E/m^2/sec$ was almost equal to that of plants grown at the higher light level.

There was no difference in length of the main stem between plants grown at the two lowest light intensities (Figure IV.6) but stems became shorter as light intensity increased above 50 $\mu E/m^2/sec$. Five weeks after emergence, the main stems of plants grown at 200 and 400 $\mu E/m^2/sec$ had almost stopped growing while those at lower light levels continued to grow throughout the experiment. The length of the newest expanded internode decreased with increasing light intensity (Figure IV.7). The difference between treatments increased with time. Very short internodes were produced on plants grown at the two higher light intensities; first on those grown at 400 $\mu E/m^2/sec$ and later also on those grown at 200 $\mu E/m^2/sec$.

Initially, leaf length was not affected by light intensity (Figure IV.8), however, 6 weeks after emergence,

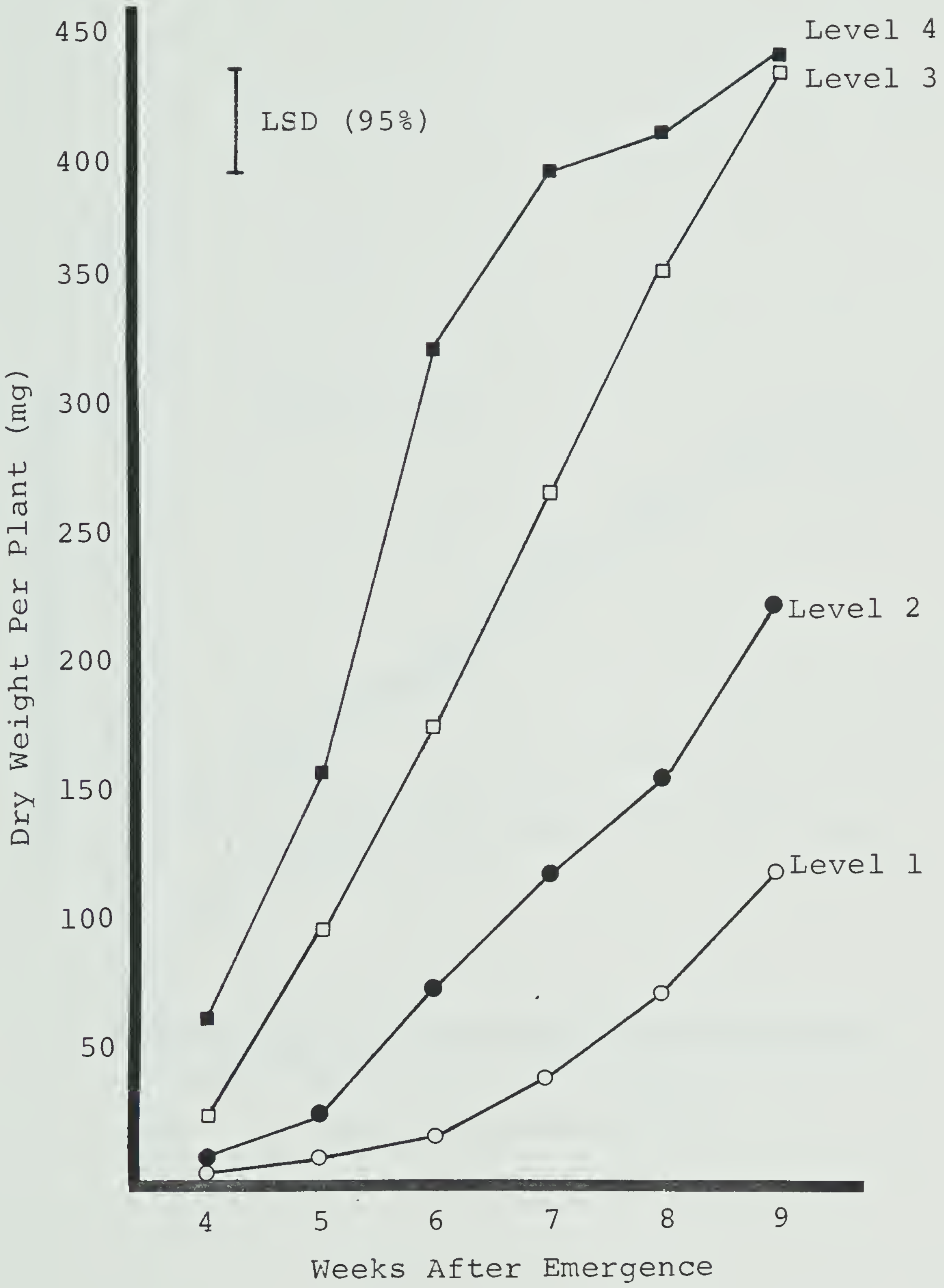

Figure IV.5 Shoot Dry Weight as Influenced by Light Intensity

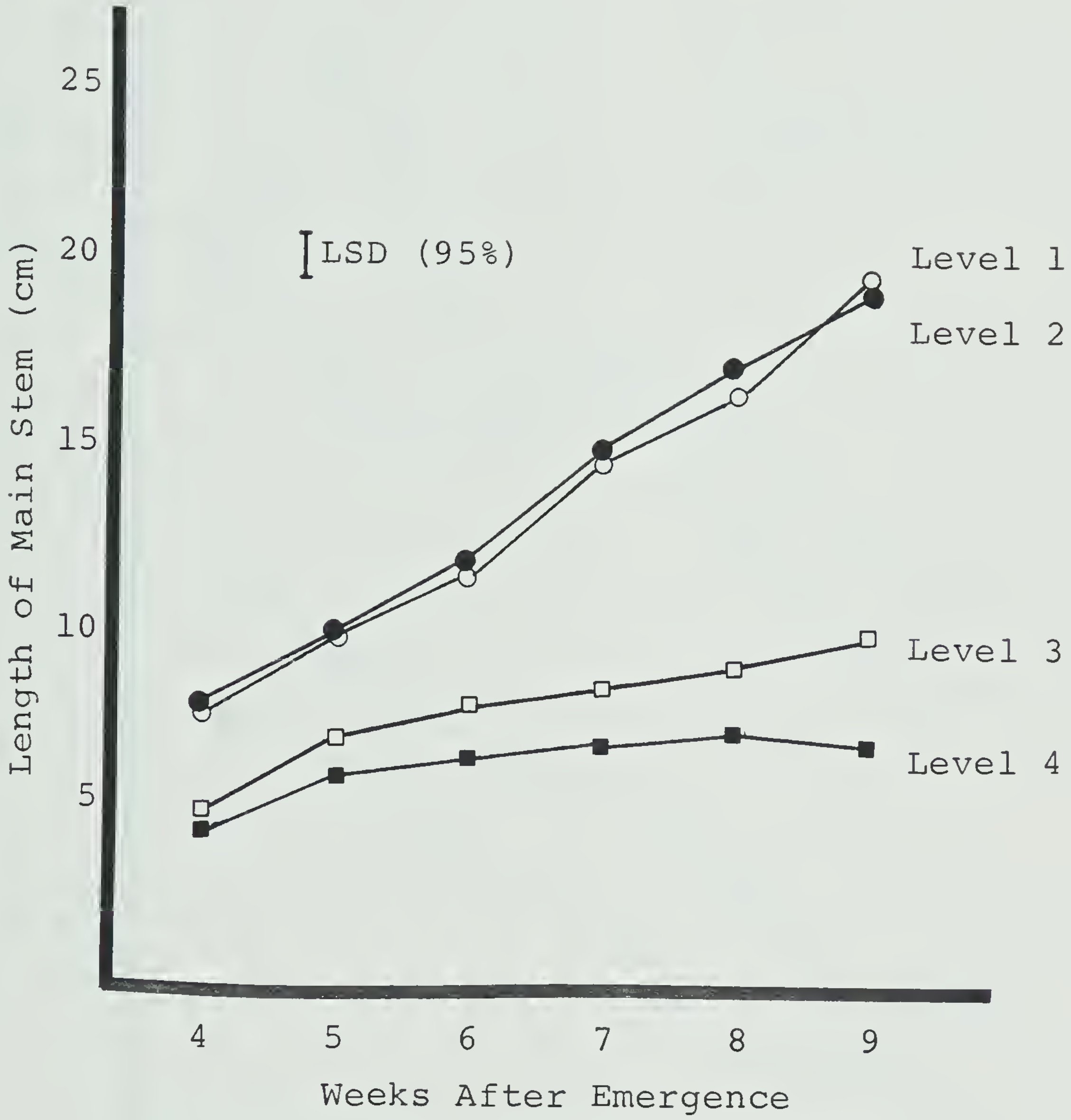

Figure IV.6 Main Stem Length as Influenced by Light Intensity

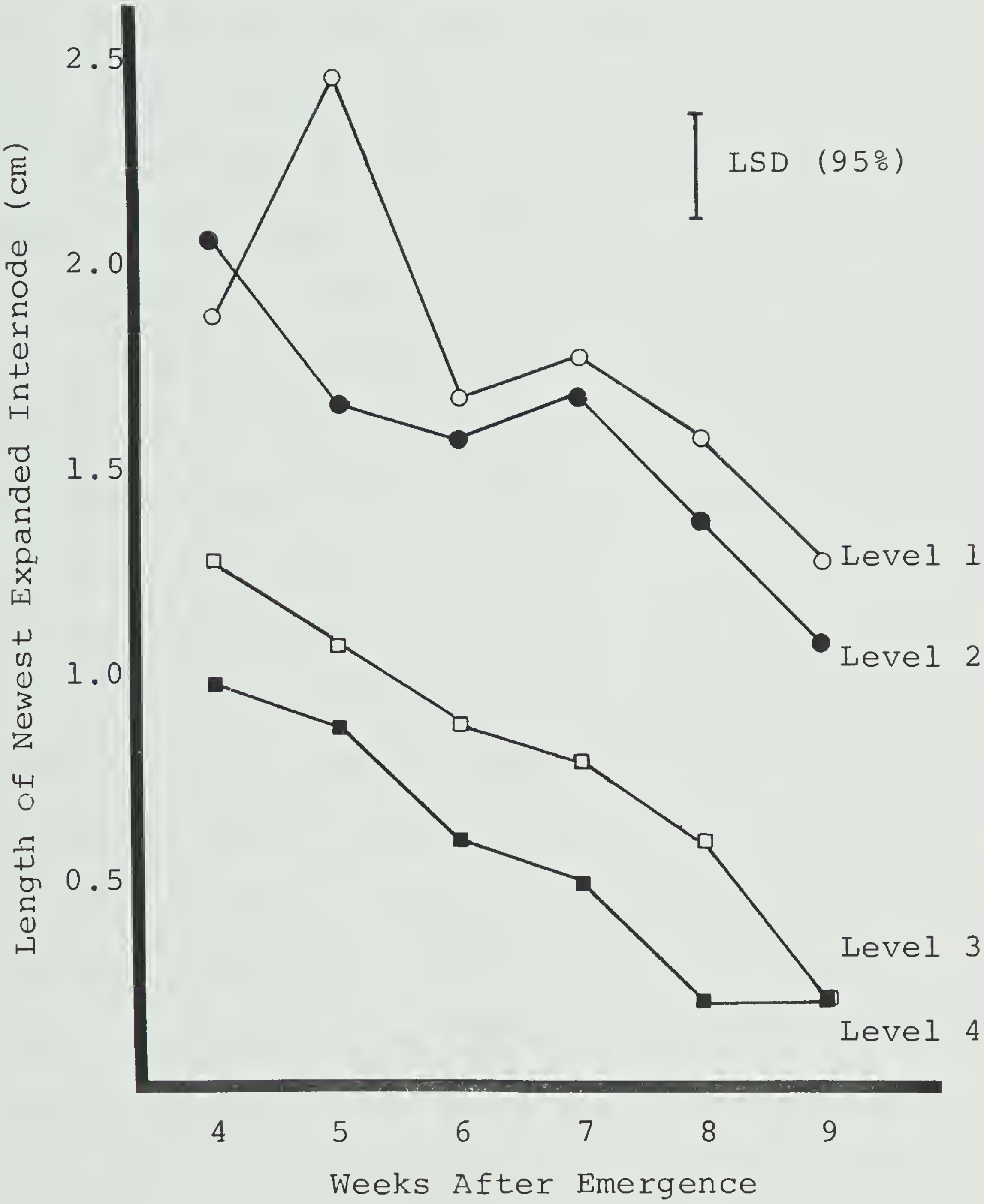

Figure IV.7 Internode Length as Influenced by Light Intensity

plants grown at 400 $\mu E/m^2/sec$ began to produce smaller leaves than those that received less light. As with the internodes, small leaves were produced first on plants grown at 400 $\mu E/m^2/sec$ and later also on those grown at 200 $\mu E/m^2/sec$. Leaf length decreased with time under all light intensities, but the decrease was more rapid at the higher light levels. The leaf ratio (length:width) was not affected by light intensity. It ranged from 1.1 to 1.6 for leaves in the vegetative portion of the plant.

The general appearance of the plants is shown in Figure IV.9. Chickweed grown at 15 $\mu E/m^2/sec$ was unbranched. The stems were weak and could not support themselves. Leaves and stems were green. With a light intensity of 50 $\mu E/m^2/sec$, the plants appeared much the same as those with less light, but they were larger and had branches from the cotyledonary leaf axils. Plants grown at 200 $\mu E/m^2/sec$ initially resembled those grown at lower light levels but later came to resemble those grown at 400 $\mu E/m^2/sec$. They will be described in detail later so comparisons can be made with all other treatments. Plants grown at 400 $\mu E/m^2/sec$ branched freely. They were more compact, with short internodes, and appeared stiffer than the others. The stems were thick and short, leaves appeared waxy and the plants were prostrate. A month after emergence, the stems and leaf tips were red. The following week the colour had deepened to a dark red-purple and the entire leaf margin was coloured. Senescence of the older leaves had begun by this time and only two to three

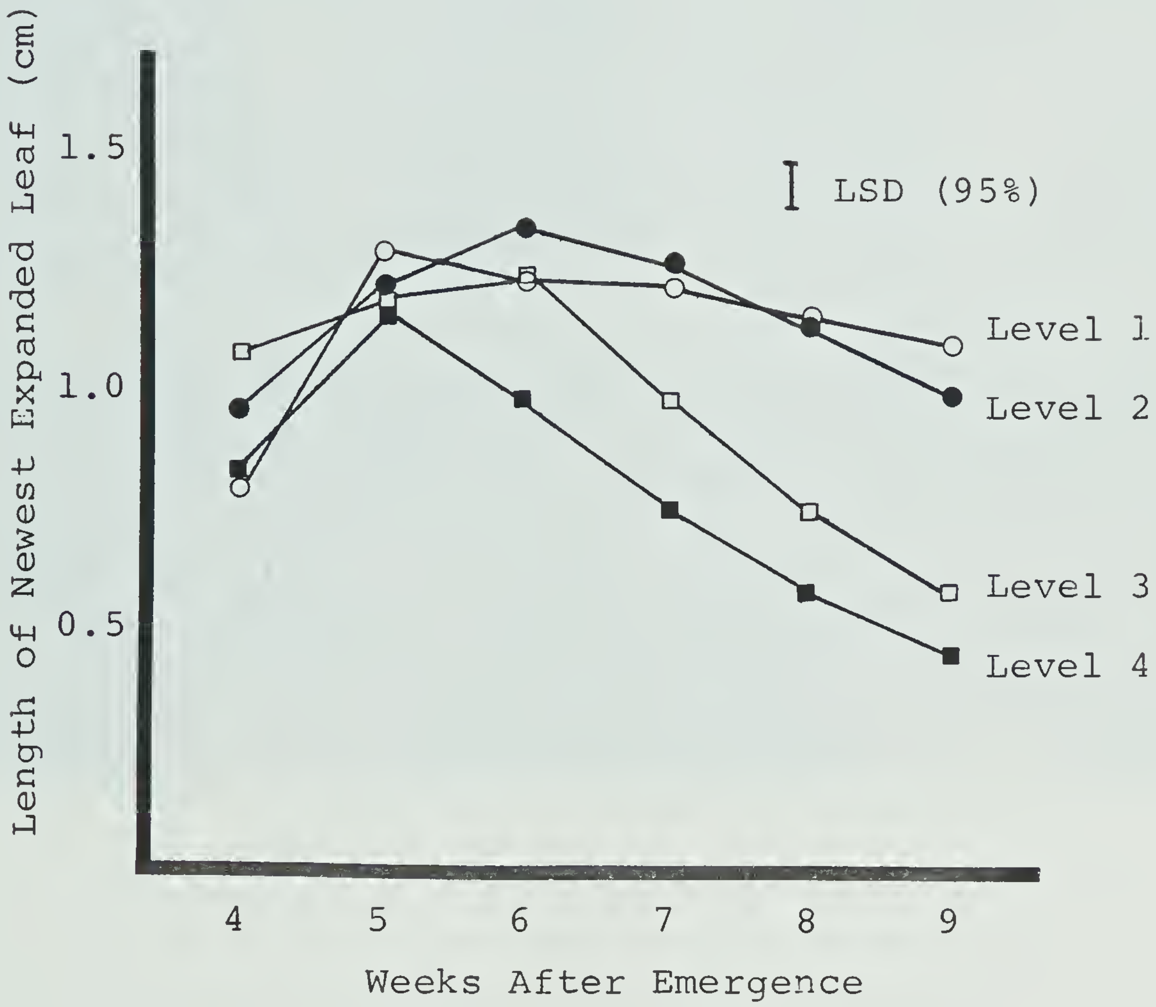

Figure IV.8 Leaf Length as Influenced by Light Intensity

Figure IV.9 Chickweed Plants Grown at Varying Light Intensities, 63 Days After Emergence

pairs of leaves at the branch tips were still green. The slowing of dry weight production by these plants that was observed towards the end of the experiment may be related to this early senescence. The plants grown at 200 $\mu E/m^2/sec$ branched more freely than those grown at lower light levels but initially they had the same general appearance. The internodes were long and the plants were green and semi-erect. Six weeks after emergence, these plants began to resemble those grown at 400 $\mu E/m^2/sec$. Shorter internodes and smaller leaves were produced and the stems and leaf tips became dark red. These plants also lost many of their older leaves, but the rate of dry matter production had not decreased by the end of the experiment.

Chickweed plants were observed in the field in varying habitats under light intensities ranging from 14 to 1650 $\mu E/m^2/sec$. There was no obvious relationship between light intensity and leaf length or leaf ratio. The leaf ratio ranged from 1.1 to 1.4 for leaves in the vegetative portion of the plant while leaves in the flowering phase had ratios of 1.5 to 2.0. Stems and leaves of plants growing in locations with less than 100 $\mu E/m^2/sec$ light did not show any red colour. At higher light intensities, red stems were found on about half of the plants observed, but there was no apparent relationship with light intensity in the range of 100 to 1600 $\mu E/m^2/sec$. Where plants grew in the open under high light intensities, they were prostrate. Chickweed growing with a crop or with other tall plants was supported

by those plants and it took on a semi-erect habit regardless of the amount of light received.

Chickweed was capable of growing and flowering under very low light intensities. Flowers were produced on plants growing at 15 $\mu E/m^2/sec$ in the field and in the growth cabinet. Growth of these plants was slow but steady. The response to high light intensity in the growth cabinet was not comparable with field observations. In the field, light intensity varies due to shading and weather conditions and photoperiod varies. Plants grown in the growth cabinet received a constant light intensity and photoperiod. They quite likely received as much total radiant energy as plants growing in field locations where measured light intensities were considerably higher. The spectral quality of the light may also affect the observed plant responses. Chickweed grown under the highest light level in the growth cabinet had short, thick stems, short internodes, small, thick leaves and red stems and leaf margins. These plants became senescent much earlier than those at lower light levels. The effect of high light intensity seemed to be cumulative as the plants grown at the next highest light intensity developed these characteristics in the latter part of the sampling period. Plants grown under low light intensities were weak-stemmed and had long internodes and larger leaves. These trends could not be picked out in field observations, possibly because the sample size was small and because many other variables such as temperature and shading were not

taken into consideration.

D. Temperature

Dry weight, internode length and leaf length are presented in Figures IV.10, IV.11 and IV.12. Data collected more than 45 days after emergence of the chickweed are not shown. These data were inconsistent because flowering occurred irregularly and all the plant characteristics that were measured were affected by flowering. Chickweed plants grown at 30°C yellowed soon after being placed in the incubator and died within 25 days of emergence.

Dry weight increased throughout the experiment except in the case of plants grown at 30°/20°C. These plants showed dry weight increases for about a month and then their growth slowed considerably. The greatest amount of dry matter was produced by plants grown at 8°C. Dry matter production decreased with increasing temperature.

The length of the main stem was variable and no difference was apparent between treatments. Internode and leaf lengths were also variable but internodes and leaves on plants grown at 8°C were clearly longer than those on plants grown at higher temperatures. The length of newly produced internodes and leaves declined as the plants grew older until flowering began, especially at 8°C and 16°C. Leaves on plants grown at 30°C and 30°/20°C were narrow in comparison with other leaves. The leaf ratio (length:width) for leaves in the vegetative portion of these plants ranged from 1.5 to

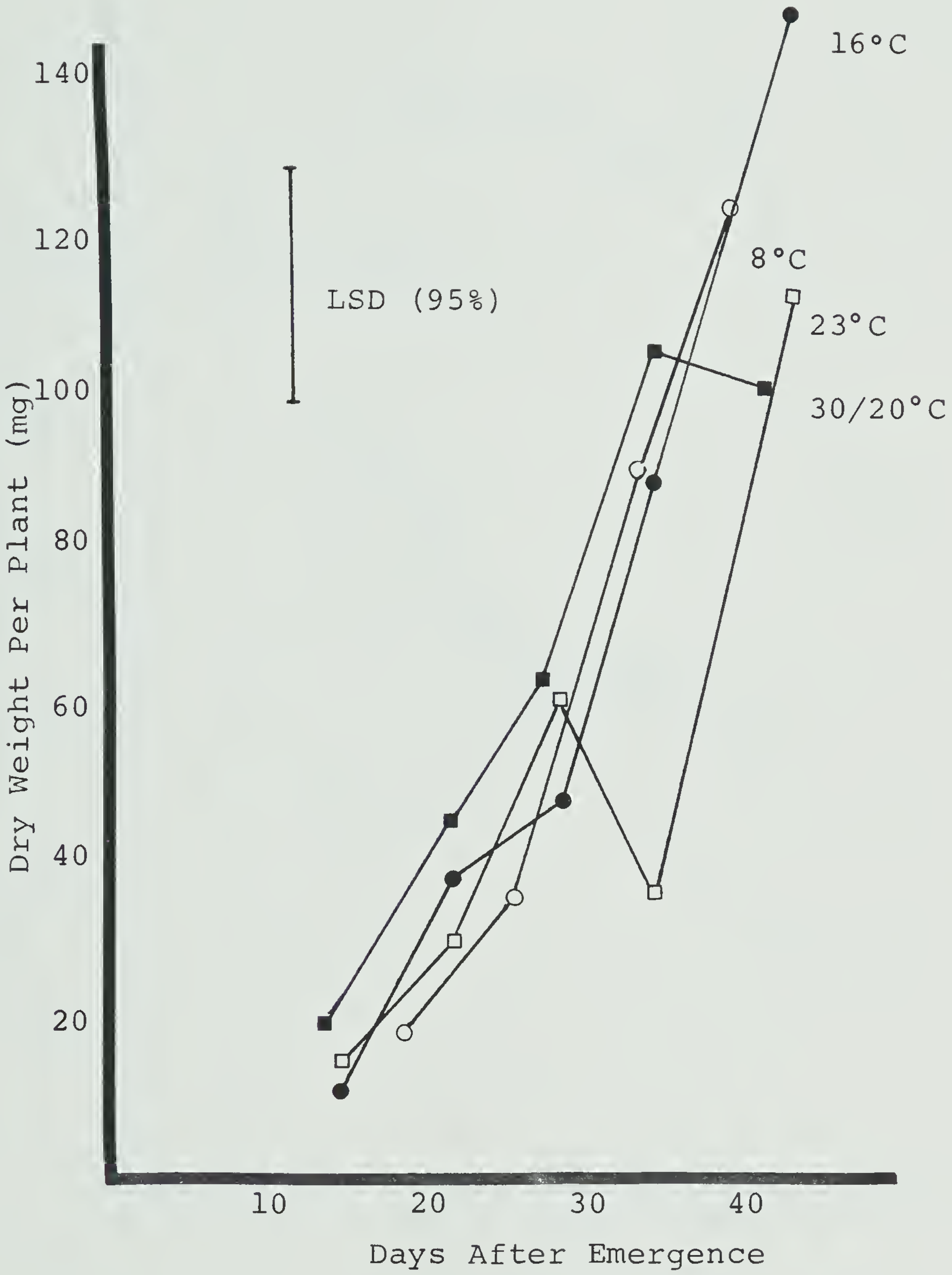

Figure IV.10 Dry Weight of Chickweed as Affected by Temperature

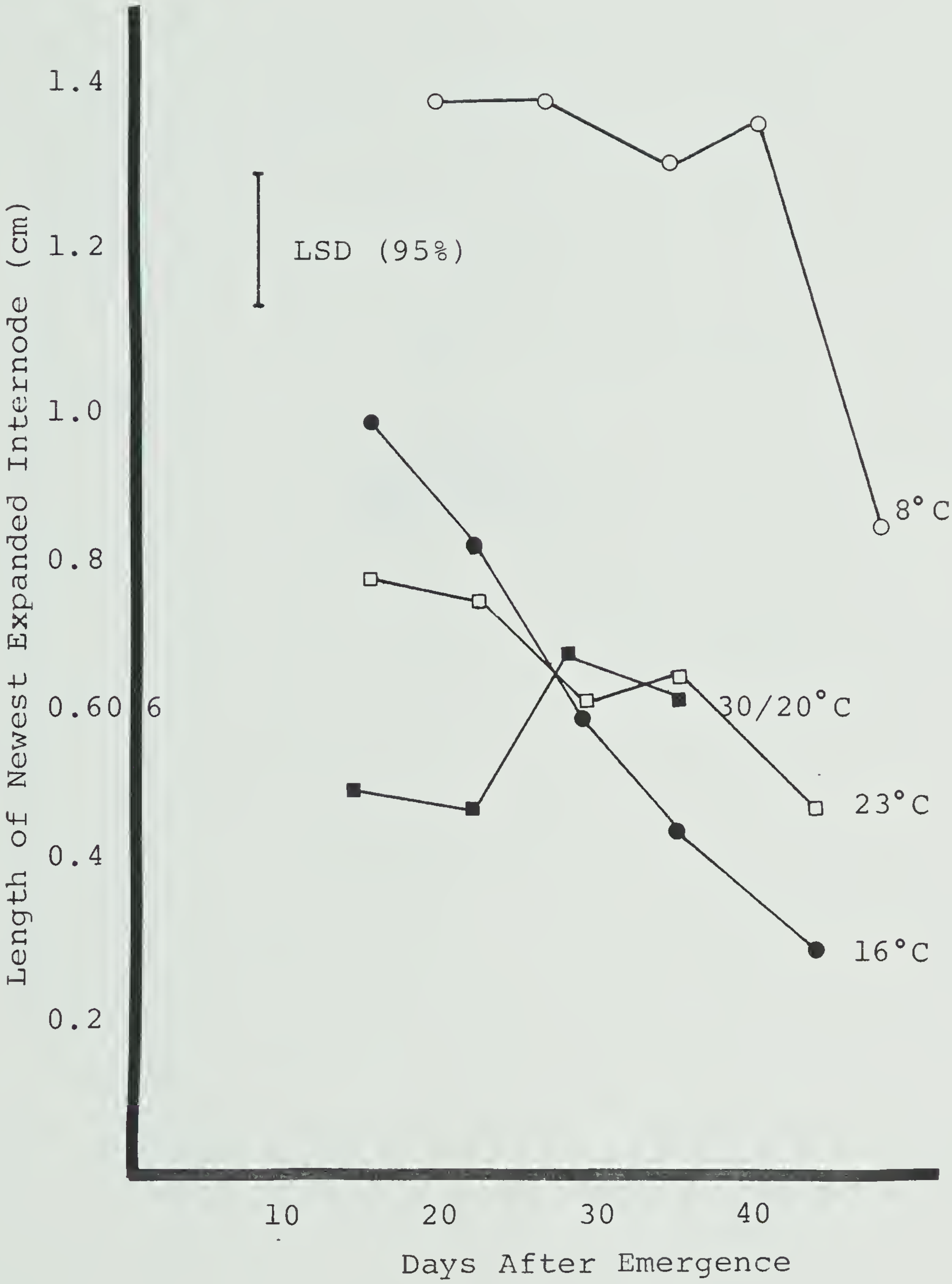

Figure IV.11 Internode Length of Chickweed as Affected by Temperature

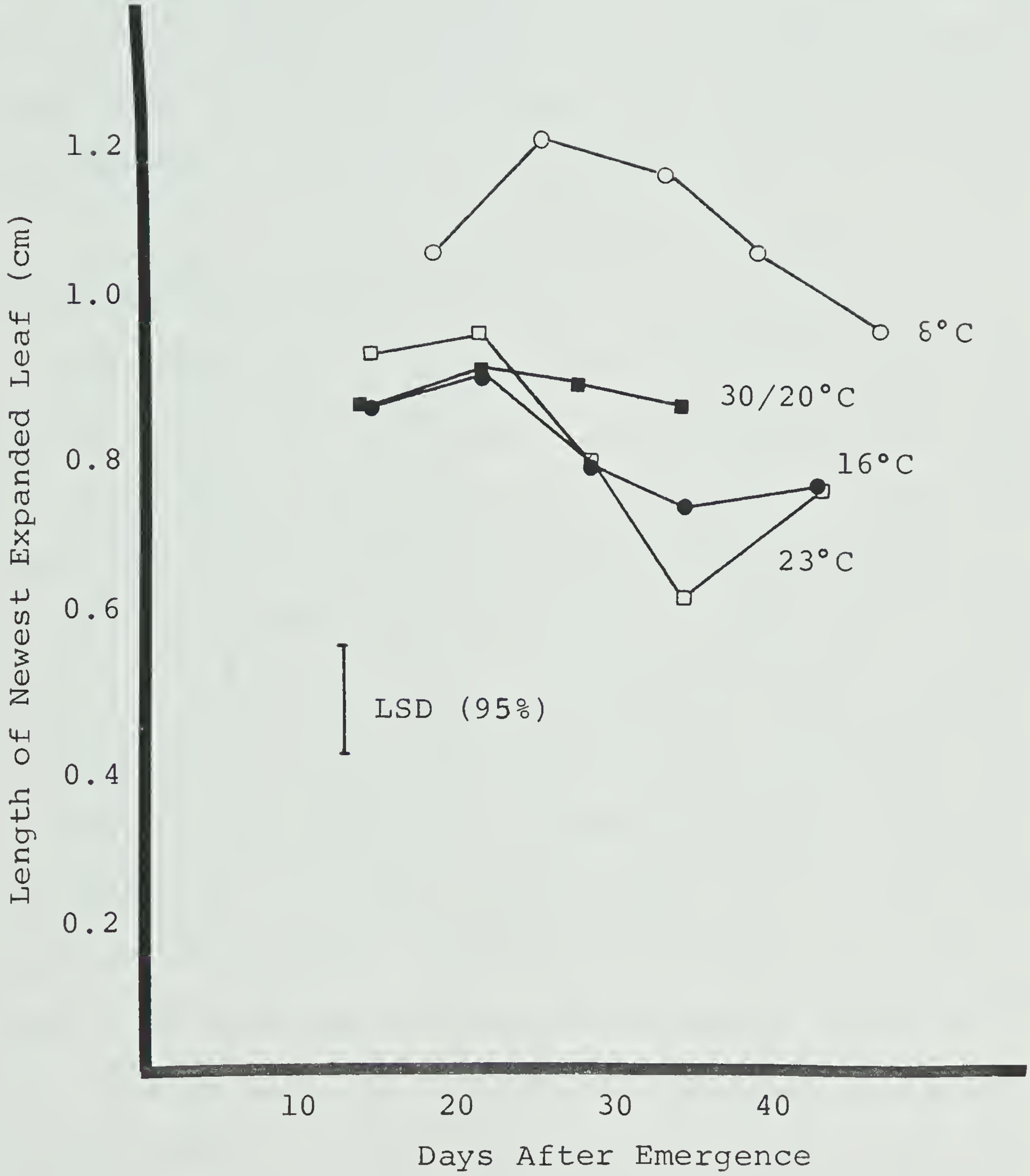

Figure IV.12 Leaf Length of Chickweed as Affected by Temperature

2.6. Leaf ratios for vegetative stage leaves on plants grown at the three lower temperatures ranged from 1.1 to 1.5.

Plants grown at 30°/20°C were abnormal in their growth habit (Figure IV.13). They branched freely but the branches were erect rather than spreading. Petioles and leaves were long. Plants grown at 8°C and 16°C were darker green and showed more red coloration than those grown at higher temperatures.

E. Soil Water Content

Chickweed plants were watered daily or after they were allowed to dry until they were on the point of wilting, until they were first visibly wilted or until they had been wilted for 2 days. Leaves were shed from all plants which were not watered daily, particularly those which remained wilted for 2 days at a time. The water stress to which chickweed plants were subjected in this experiment did not kill any of the plants, but growth decreased visibly with restriction of available water (Table IV.10). The difference in dry weight between treatments increased with time. Stem length also decreased with declining water supply (Table IV.11). These observations were not unexpected because cellular growth is sensitive to water stress (38). The length of internodes and the size of leaves were not affected by water stress, nor was the leaf ratio (length:width).

Figure IV.13 Chickweed Plants Grown at Varying Temperatures

Table IV.10 Dry Matter Production of Chickweed Grown Under Four Soil Moisture Conditions

Treatment	Dry Weight (mg/plant) Harvest Date June 16	June 27	July 7
Watered daily	1575 a[1]	3160 a	6697 a
Dried to the point of wilting	750 b	2105 b	3467 b
Allowed to wilt	542 bc	1590 bc	2680 c
Wilted 2 days	397 c	945 c	1550 d

[1]Numbers within columns followed by the same letter are not significantly different at the 95% level, according to Duncan's multiple range test.

Table IV.11 Stem Length of Chickweed Grown Under Four Soil Moisture Conditions

Treatment	Main Stem Length(cm) Harvest Date June 16	June 27	July 7
Watered daily	19 a[1]	38 a	45 a
Dried to the point of wilting	17 a	25 b	34 b
Allowed to wilt	14 c	26 b	32 b
Wilted 2 days	12 d	16 c	22 c

[1]Numbers within columns followed by the same letter are not significantly different at the 95% level, according to Duncan's multiple range test.

The experiment was done to determine if chickweed was capable of surviving in dry situations. It did survive the conditions that were imposed, but no other species were included in the experiment for comparison. In an experiment by Wiese and Vandiver (54), ten plant species were grown together under three soil moisture regimes. Six of the ten species produced more dry matter on wet soil than on dry soil, two species were unaffected by soil moisture and two species produced more growth on dry soil than on wet soil. Although experimental conditions were not the same in the two studies, it is likely that chickweed was not as well adapted to low soil moisture conditions as were the latter four species in Wiese and Vandiver's study, and it would likely be at a competitive disadvantage with at least some species, under low soil moisture conditions.

F. Competition

Intraspecific Competition

Chickweed was grown alone at densities ranging from 1 to 100 plants per 12.5-cm pot. At the first sampling time, dry weight per pot increased with increasing density (Figure IV.14). Later harvests showed a levelling off of dry weight per pot at a density of 10 to 25 plants per pot. Competition for resources limited the growth of individual plants at the higher densities and resulted in a limit to the amount of dry matter produced in one pot. At the first harvest, there was already some competition occurring between plants at

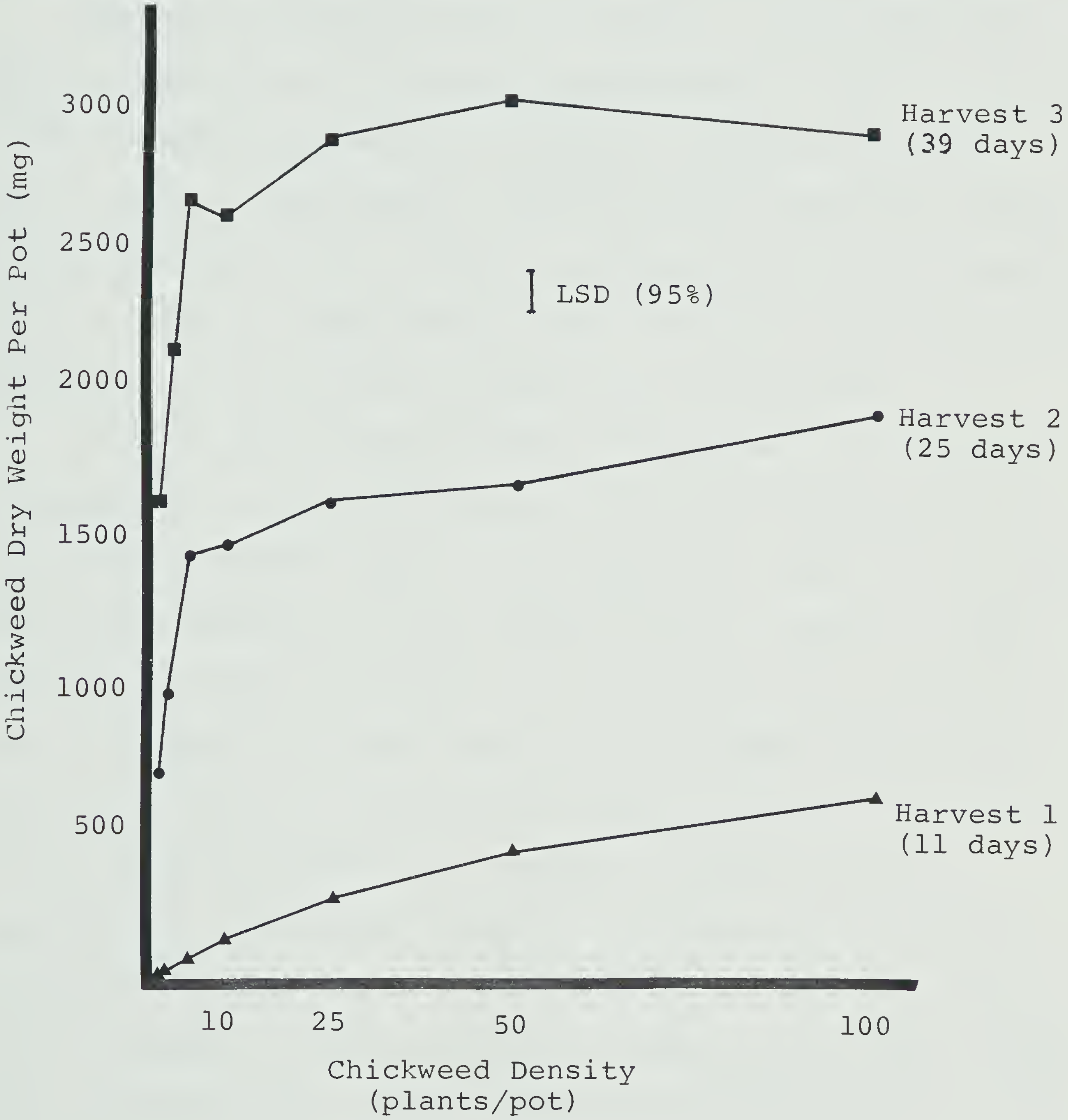

Figure IV.14 Chickweed Shoot Dry Matter Production per Pot at Varying Densities

densities of 50 and 100 plants per pot, resulting in a decrease in dry weight per plant at those densities (Figure IV.15). At later harvests, the dry weight per plant declined rapidly with increasing density to 10 plants per pot. At higher densities, dry weight per plant declined more slowly.

Length of the main stem was greater at high densities than at lower ones at the first two harvests (Table IV.12). Plants in the high density treatments shaded each other early in their development, and therefore elongated rapidly. By the second harvest, plants at medium densities had caught up with those at higher densities, and at the final harvest there was no difference in height due to treatment.

Size of the earliest leaves produced was not affected by competition among the plants, but there was some effect on leaves produced later in the vegetative stage. The fourth true leaf, measured at the second harvest, showed a slight decline in length with density, especially above 25 plants per pot. Length of these leaves at the highest density was about half that of leaves at the lowest density. There was little effect of density on length of leaves in the reproductive portion of the plant. By the time the plants reached that stage, growth had levelled off and there was a similar amount of plant material in each pot so these leaves were produced under similar conditions regardless of initial density.

The leaf ratio (length:width) was not affected by density. It was 1.0 to 1.3 for leaves in the vegetative part

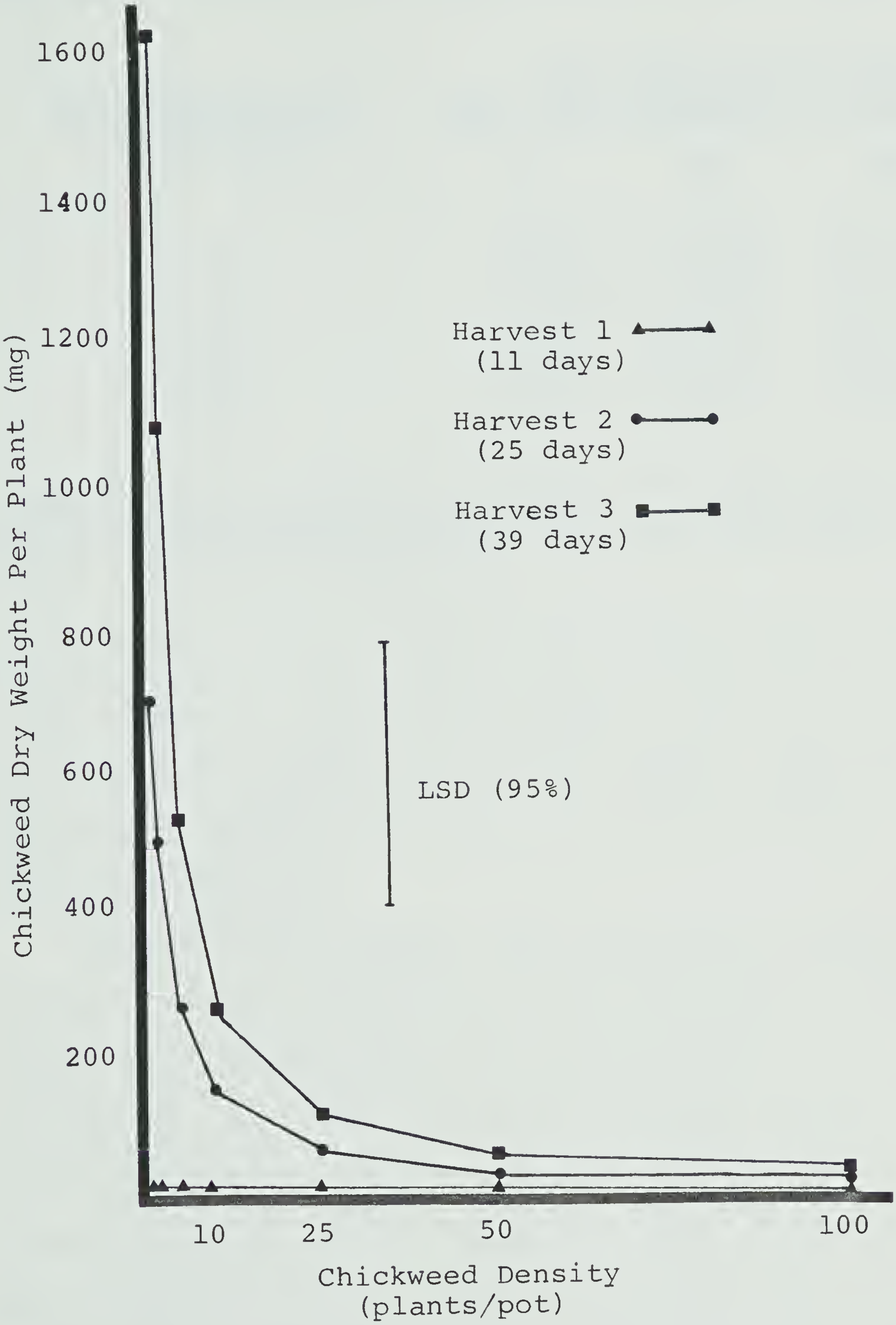

Figure IV.15 Chickweed Shoot Dry Matter Production per Plant at Varying Densities

Table IV.12 Length of Chickweed Main Stems as Affected by Density

Chickweed Density (plants/pot)	Main Stem Length (cm) Days from Emergence to Harvest		
	11	25	39
1	0.2 e[1]	17.6 b	44.0 a
2	0.4 e	15.6 b	50.3 a
5	1.0 de	16.9 b	51.0 a
10	1.9 d	20.0 a	47.0 a
25	4.4 c	22.4 a	46.3 a
50	8.0 b	20.0 a	49.0 a
100	12.1 a	20.9 a	44.8 a

[1]Numbers within a column followed by the same letter are not significantly different at the 95% level according to Duncan's multiple range test.

of the plant, 1.4 to 1.7 for leaves immediately below the first flower, 1.7 to 2.0 for leaves at the first flower and 2.0 to 2.4 for leaves at the third flower. These leaf ratios agree quite closely with those reported by Komatsu (23) for *Stellaria neglecta*.

Branching was reduced when chickweed was grown at densities above 10 plants per pot. Chlorosis of the lower leaves progressed most quickly at high densities, likely due to lack of light near the base of the plant mass. It was quite moist within the chickweed stand, particularly where there was a high density of plants. Many adventitious roots were formed on the lower part of the stems when the plants were grown at densities greater than 10 plants per pot. At lower densities, the stands were not as moist and the plants did not root as freely. Some adventitious roots were still

formed, mainly at nodes that touched the ground.

Competition with Barley

Regression equations were calculated and are shown on the graphs. The coefficients of determination (r^2) indicate the percentage of the relationship between the variables that is described by the regression equation.

The first experiment in this series was designed to test the effect of chickweed density on barley growth. Four barley plants were seeded with 1 to 100 chickweed plants in 12.5-cm pots. As expected, barley dry weight declined as chickweed density increased (Figure IV.16). Fifteen days after emergence, the decline in barley dry weight was only slight but it increased as time went on. The greatest decline in barley dry weight with increasing chickweed density was observed at the final harvest, 35 days after emergence of the plants.

At the first harvest, the barley had not yet begun to tiller. During the course of the experiment not all barley plants tillered at any given chickweed density, nor did many plants produce more than one tiller. The maximum number of tillers was observed at the second harvest, after which some tillers were lost. The data were somewhat variable, but there was a definite trend toward fewer tillers as chickweed density increased up to 25 plants per pot (Figure IV.17).

The development of leaf stage and growth in height of the barley were not affected by chickweed at any of the

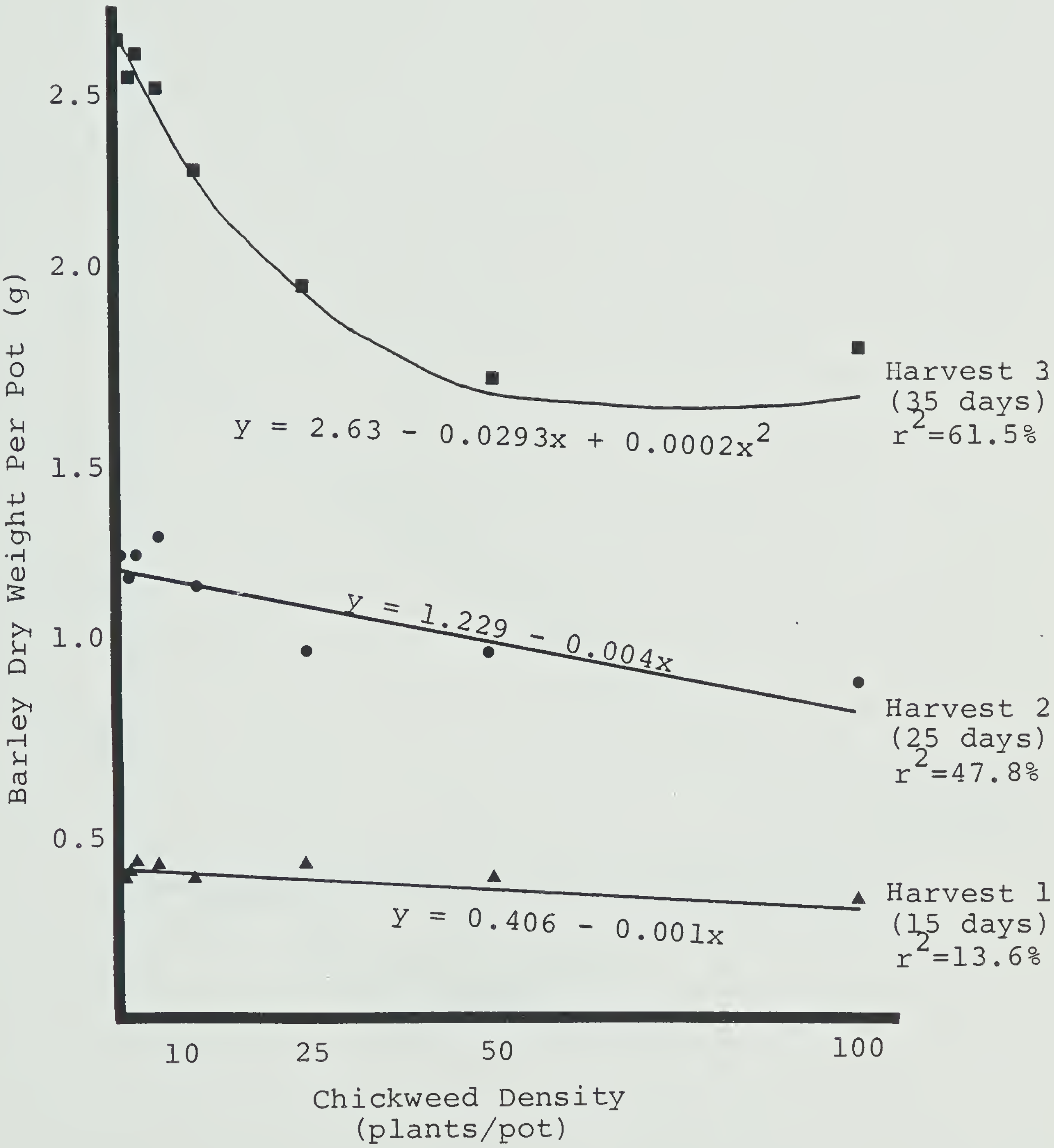

Figure IV.16 Barley Dry Weight as Affected by Competition with Chickweed at Densities from 1 to 100 Plants per 12.5-cm Pot

Based on 32 data pairs.
Points plotted are the average of four observations.

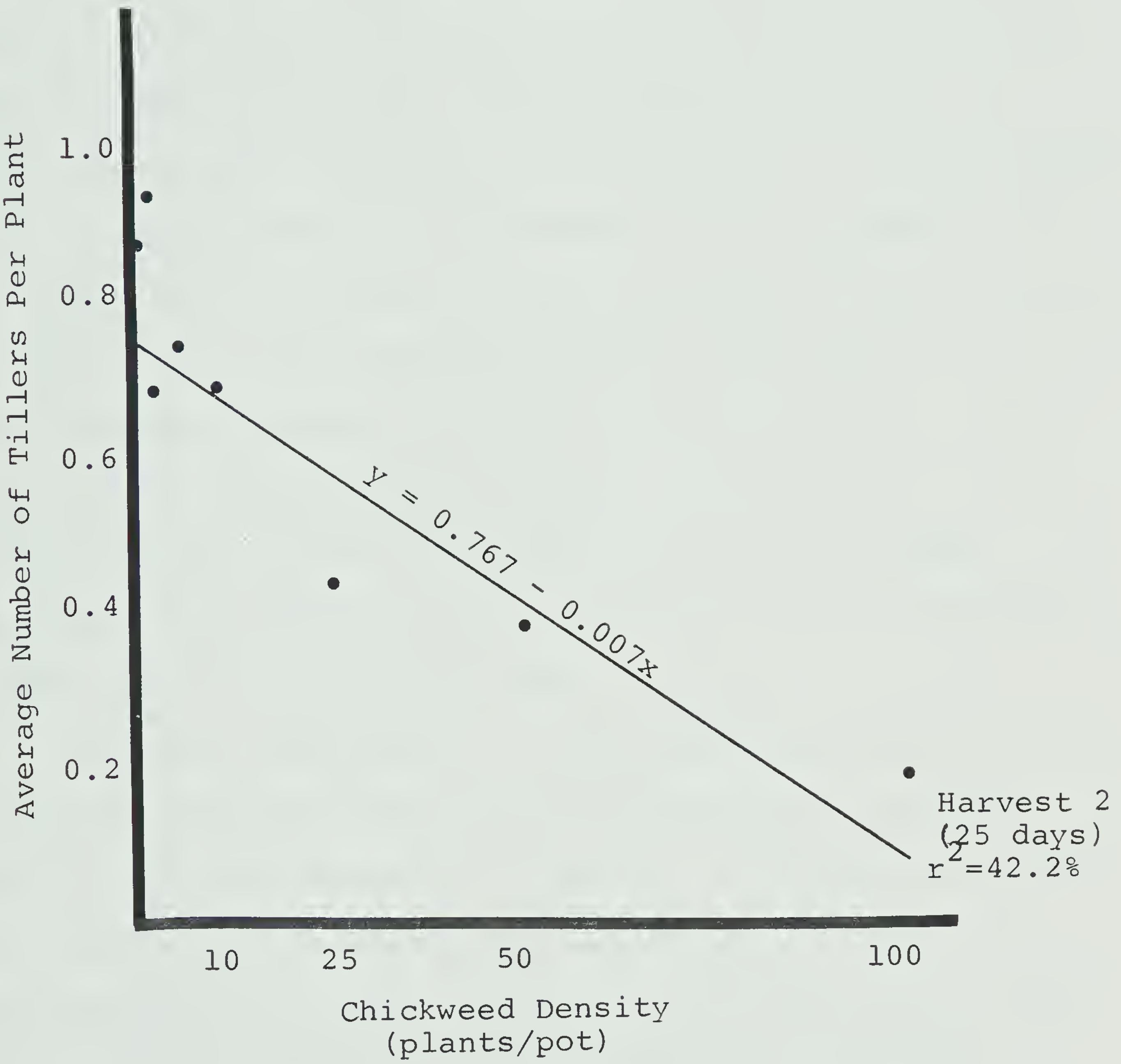

Figure IV.17 Maximum Number of Barley Tillers per Plant as Affected by Competition with Chickweed at Densities of 1 to 100 Plants per 12.5-cm Pot

Based on 32 data pairs.
Points plotted are the average of four observations.

densities used.

In an experiment by Mann and Barnes (26) with two barley plants and one to eight chickweed plants per pot, tillering was reduced by all chickweed densities, and the shoot weight of barley was reduced by 50 to 90% from the control. In contrast, the results reported here show much smaller reductions in dry matter produced by barley in competition with chickweed. The difference in results cannot be fully explained by the difference in barley density. It is likely that variations in growing conditions and possibly barley cultivar and chickweed ecotype play major roles in the outcome of competition between the two species. These experiments indicate that chickweed has the potential to reduce barley yields, but no conclusions can be made regarding the extent of yield reduction except under the conditions of a given experiment.

Two other experiments in this series were designed to study the effect of the time of emergence of a constant density of chickweed on barley growth. Chickweed was grown at a density of 35 plants per 12.5-cm pot in the first experiment and 15 plants per pot in the second experiment, with planting timed to result in emergence from about 2 weeks before to 2 weeks after the barley.

When chickweed was grown at a density of 35 plants per pot, barley dry weight was reduced with earlier emergence of the chickweed.(Figure IV.18). This trend increased with time so that the greatest difference between treatments was

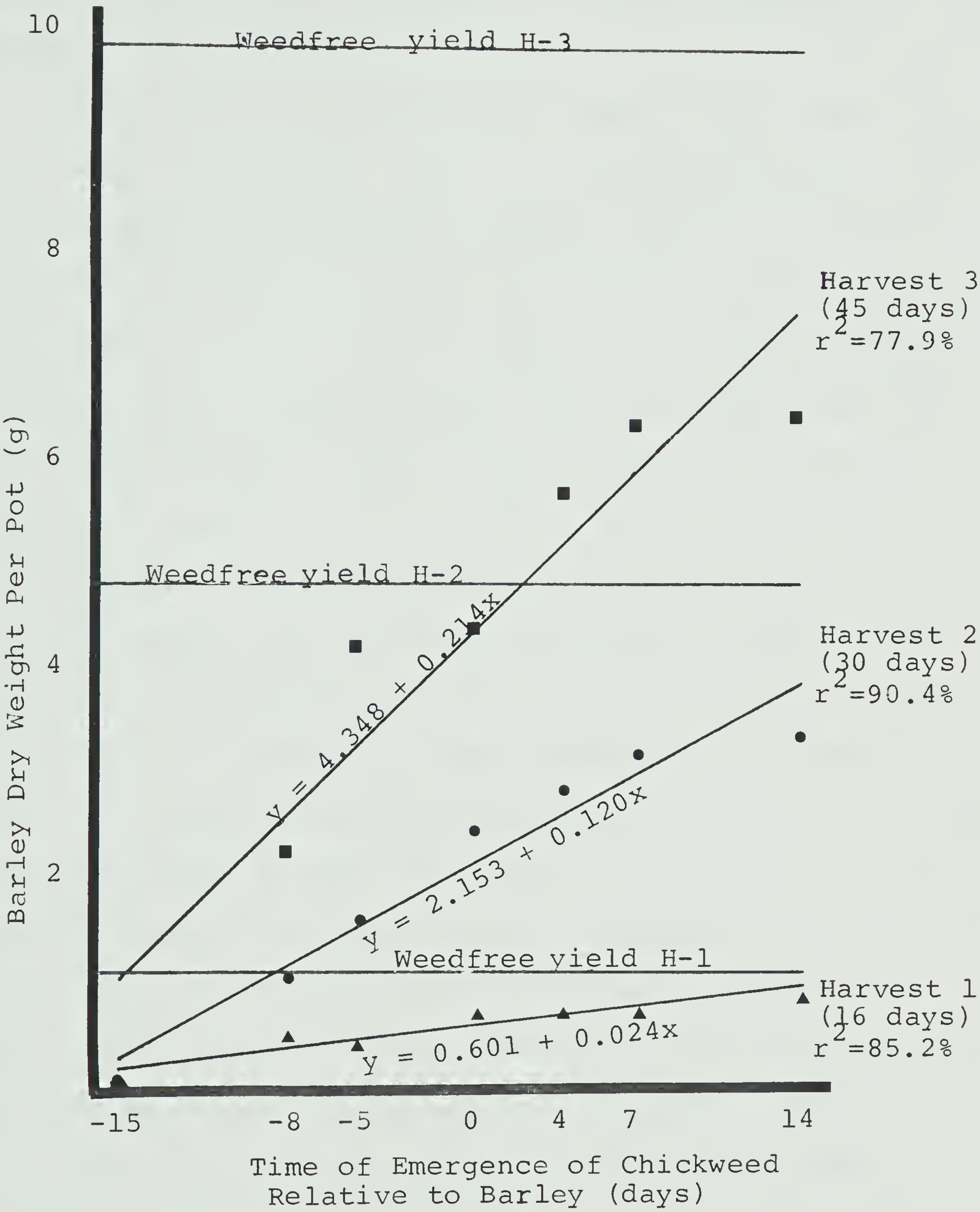

Figure IV.18 Barley Dry Weight as Affected by Time of Emergence of Chickweed at a Density of 35 Plants per 12.5-cm Pot

Based on 28 data pairs.
Points plotted are the average of four observations.

observed at the last harvest. When the chickweed emerged 15 days before the barley, the barley grew very little. The rate of barley growth increased with later emergence of the chickweed.

The barley plants tillered but some tillers were lost before the third harvest. Data for the second harvest, the maximum number of tillers, are shown (Figure IV.19). No tillers were produced when the chickweed emerged 8 or 15 days before the barley. The number of tillers produced increased rapidly during the period of chickweed emergence from 5 days before to 4 days after the barley, while later emerging chickweed had little effect on barley tillering.

The number of heads produced per pot was recorded at the final harvest, 45 days after emergence (Figure IV.20). Heading was not complete at this time and there were some tillers still in the boot stage. These were not counted as heads. Early emerging chickweed reduced barley heading. When the weed emerged 15 days before the barley, no heads were produced. Maximum heading, in pots containing chickweed, was reached when the chickweed and barley emerged together; however, the number of heads produced in these pots did not approach the number produced in weedfree pots. This discrepancy is not explained readily as the chickweed that emerged 14 days after the barley did not grow to a height of more than 7 cm and it seems unlikely that this would provide sufficient competition to reduce barley heading.

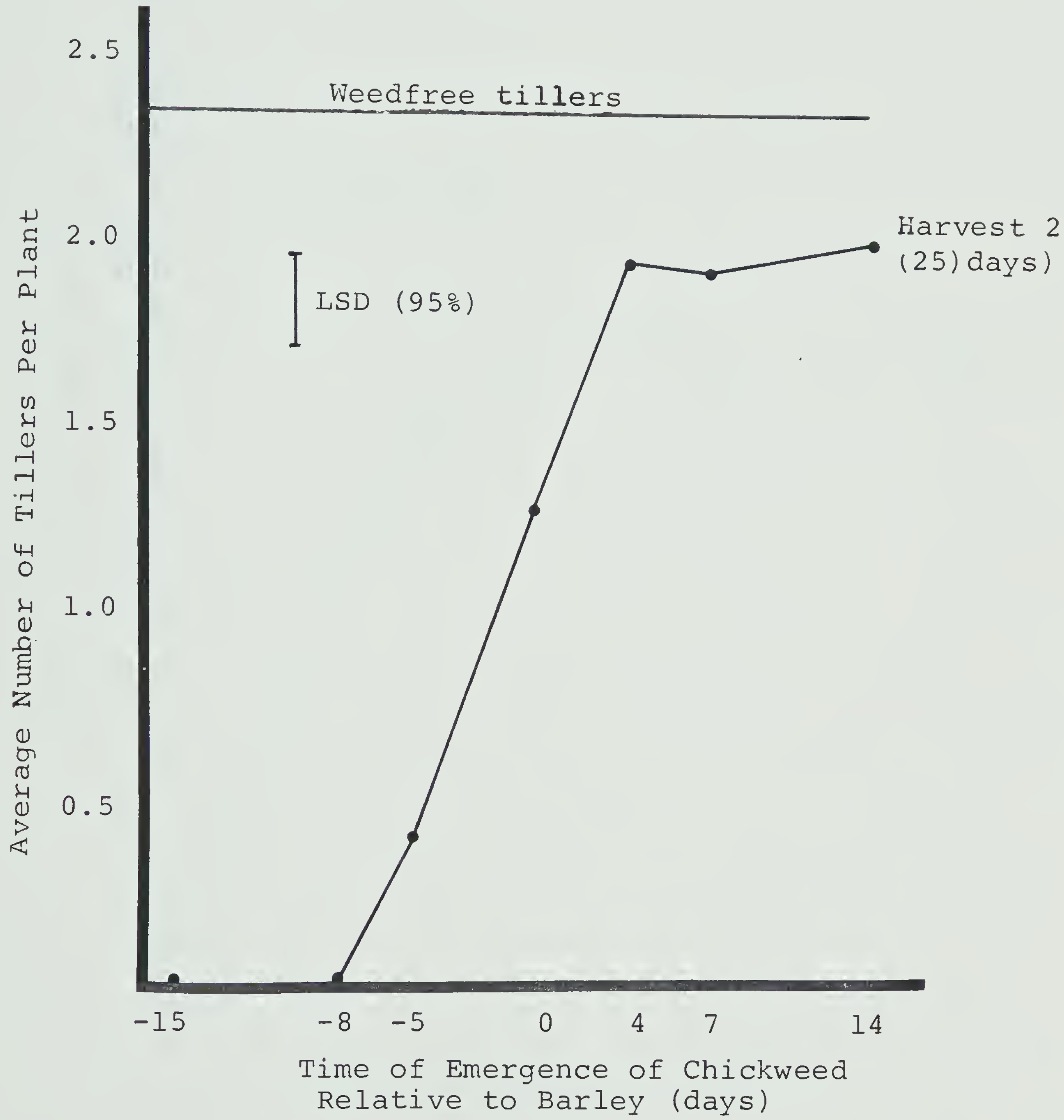

Figure IV.19 Maximum Number of Tillers per Barley Plant as Affected by Various Times of Emergence of Chickweed at a Density of 35 Plants per 12.5-cm Pot

Based on 28 data pairs.
Points plotted are the average of four observations.

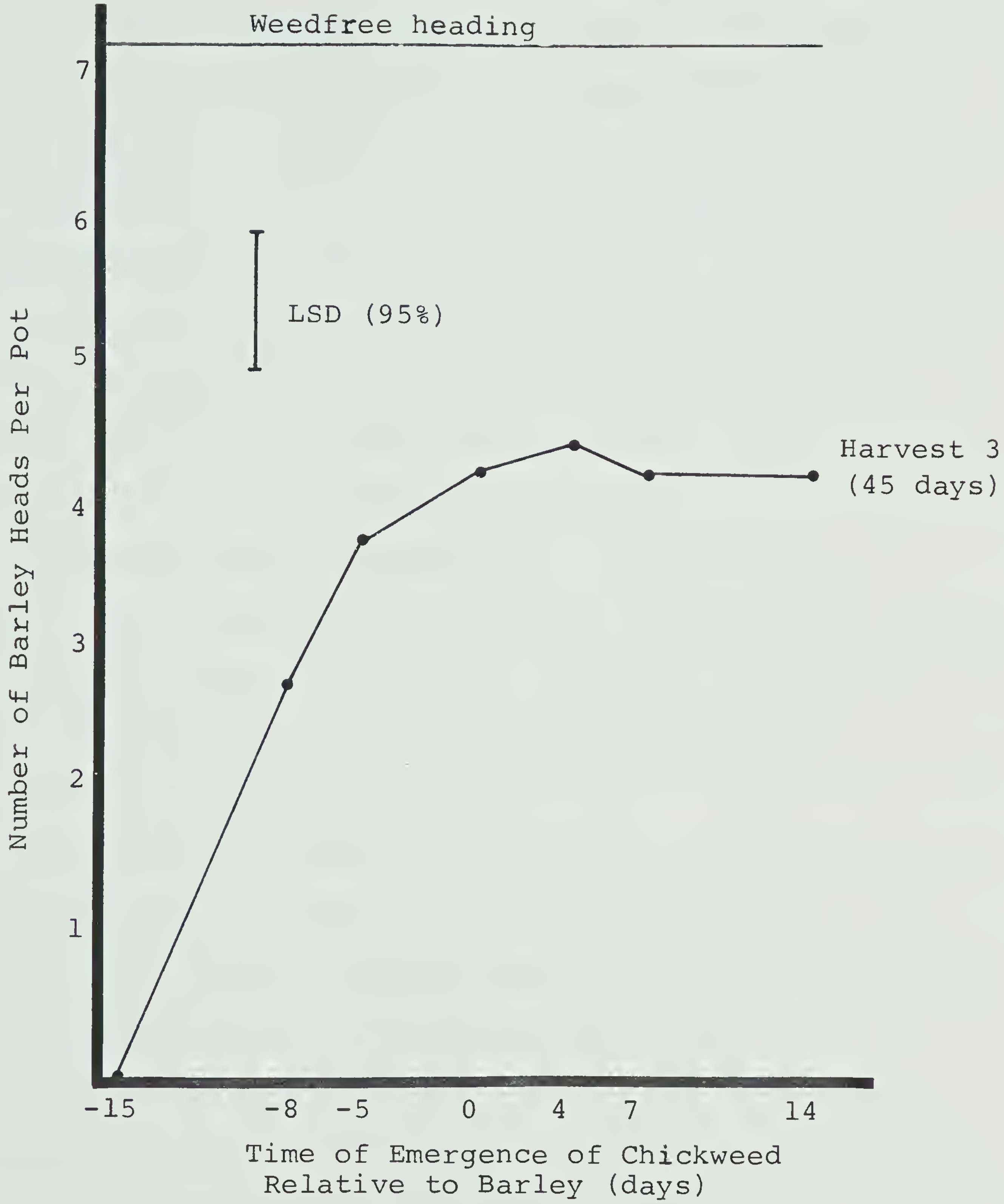

Figure IV.20 Heading of Barley as Affected by the Time of Emergence of Chickweed at a Density of 35 Plants per 12.5-cm Pot

Based on 28 data pairs.
Points plotted are the average of four observations.

The rate of development of barley, as indicated by leaf stage, was slowed considerably when chickweed emerged 15 days before the barley. Thirty days after emergence, the barley in that treatment had an average of 2.8 leaves. The average barley leaf stage when chickweed emerged later ranged from 6.8 to 7.5, 30 days after barley emergence.

The height of barley plants was variable, but when chickweed emerged 15 days before the barley, the barley was only about half as tall as it was in other treatments. At the final harvest, barley grown in competition with the earliest emerging chickweed was 36 cm tall, while plants in the other treatments ranged from 85 to 98 cm in height.

Chickweed growth was affected by its interaction with barley. When it emerged 15 days before the barley, chickweed grew rapidly. In contrast, when it emerged 14 days after the barley it grew very little in the month before the experiment was terminated.

The second experiment in which the time of emergence of chickweed was varied had a density of 15 chickweed plants per pot. The times of emergence were similar to those in the previous experiment. In this experiment, there was a reduction in barley dry weight with earlier emergence of chickweed (Figure IV.21), however, the effect of chickweed on barley was less than in the previous experiment. The rate of dry matter production by barley in this experiment was markedly lower than in the previous one. This was likely due to differences in greenhouse growing conditions between the

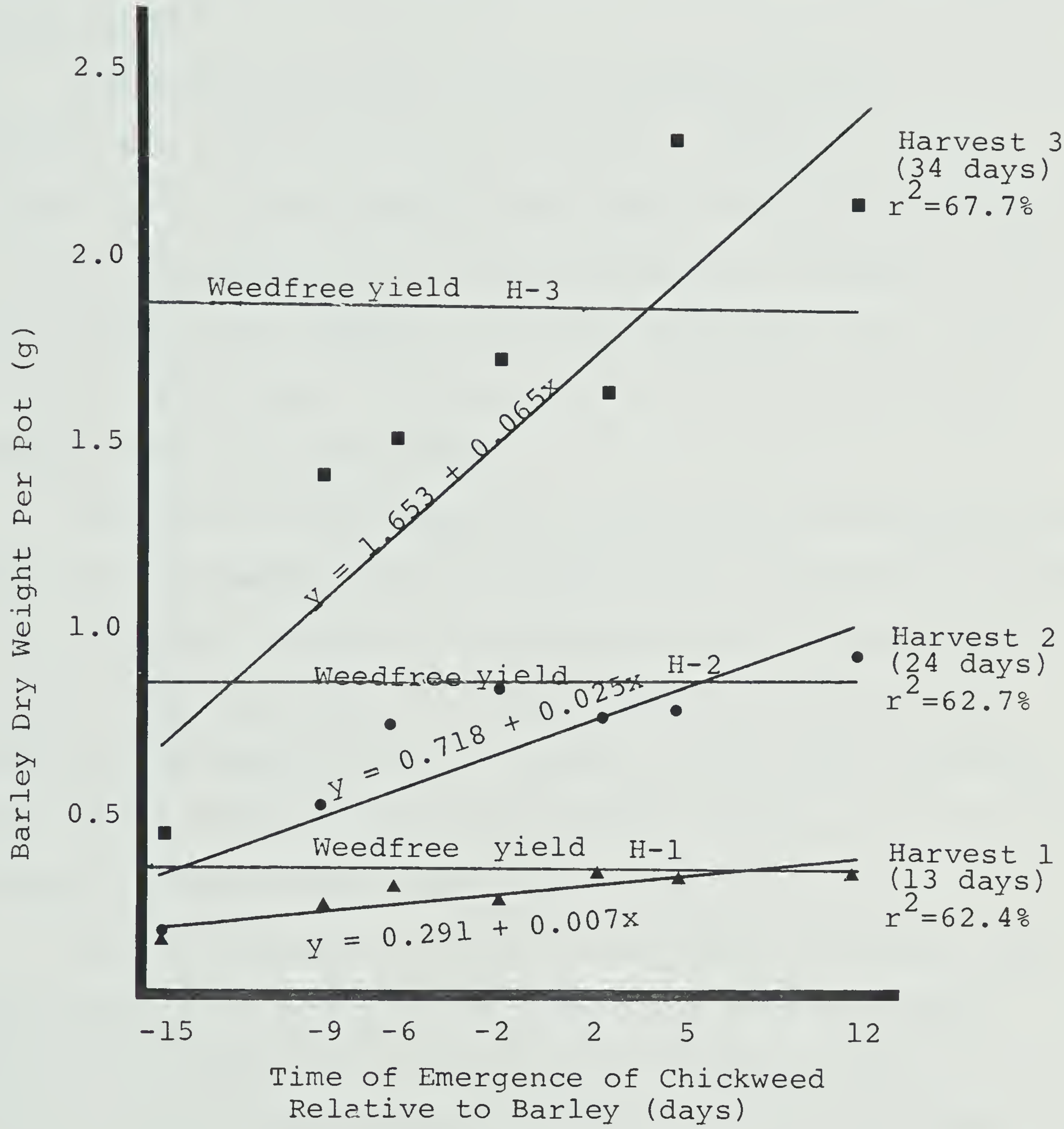

Figure IV.21 Barley Dry Weight as Affected by Time of Emergence of Chickweed at a Density of 15 Plants per 12.5-cm Pot

Based on 28 data pairs.
Points plotted are the average of four observations.

two experiments. The greenhouse temperature was about 5°C higher in this experiment than in the previous one. The difference in timing of the harvests should also be noted. As a result of these variations in procedure it is necessary to take great care in making comparisons between the two experiments.

There were very few tillers produced in this experiment, and there was no treatment effect on tiller production. It was expected that more tillering would occur in this experiment with a lower density of chickweed than in the previous one, however, this did not occur. This result is also likely due to differences in growing conditions between the two experiments.

The rate of development of the barley was affected only when the chickweed emerged 15 days before the barley. At the final harvest, 34 days after emergence, the average leaf stage of barley plants in competition with the earliest emerging chickweed was 3.5. Plants in the other treatments had 6 to 7 leaves at that time. These results are similar to those of the previous experiment.

Barley height was variable, as it was in the previous experiment, but again it was clear that when chickweed emerged 15 days before the barley, the barley grew very slowly. It attained a height of 37 cm, in this treatment, by the final harvest, whereas barley in the other treatments was 69 to 75 cm tall.

The rate of chickweed dry matter production was affected by competition with the barley in a manner similar to the previous experiment. When chickweed emerged 12 days after the barley, it grew very little. Earlier emerging chickweed grew more rapidly.

The effect of chickweed on barley in this experiment was apparent mainly when chickweed emerged 15 days before the barley. This early emerging chickweed reduced barley dry weight and slowed development through the leaf stages and growth in height of the barley. Generally, the effect of chickweed on barley was similar to that observed in the previous experiment, but it was less severe with the lower density used in this experiment. The exception to this occurred when chickweed emerged 15 days before the barley. In this case, barley growth was severely affected in both experiments. In both experiments, the rate of chickweed dry matter production was reduced by competition with barley. The later emerging chickweed grew slowly in comparison with that which emerged 15 days before the barley.

The experiments in this series indicate that chickweed is very plastic in its growth in response to the density at which it emerges. A small number of chickweed plants are capable of producing as much dry matter as a large number of plants, where resources are limited. Competition with barley reduced this ability somewhat, however, it appears that the density of chickweed was not as critical to its competitive effects on barley as was its time of emergence. When

chickweed emerged 2 weeks before the barley, its density was not important. When the two species emerged together, increasing chickweed density had some effect on barley but it was not as great as the effect of early emergence of chickweed.

These pot experiments were designed to minimize the differences between growing conditions in pots and in the field as much as possible . The pots were shielded to provide support for the chickweed plants, which they would receive from other plants in the field, and to reduce incident light from the sides of the pots. An attempt was made to maintain fertility, and the plants were not left to maturity in order to reduce the effect of limited rooting volume. It is apparent that chickweed has the ability to reduce barley growth and heading under the circumstances of these experiments; however, they provide only an indication of what may happen in a field situation. Field experiments would be necessary to make an accurate assessment of that situation.

G. Control

Greenhouse Experiment

The herbicides used in this experiment were divided into two groups that were handled as separate experiments. Both groups were sprayed when the chickweed had four leaf pairs or when it had seven to eight leaf pairs. Linuron/MCPA was included in both groups for comparison. Control with

this treatment was slightly better in the first group than in the second group, especially at the lower rate (Tables IV.13 and IV.14). A significant difference between groups (Student's t-test, 95% probability) was found only for the lower rate of linuron/MCPA sprayed on plants with seven to eight leaf pairs. The MCPA in this mixture caused chickweed leaves and stems to curl up one day after spraying. The leaves remained small and eventually became necrotic. Linuron/MCPA was most effective when sprayed on young plants.

Plants sprayed with metribuzin showed interveinal necrosis 4 to 5 days after spraying. This symptom was first observed on the upper leaves just below the growing point, the youngest leaves present at the time of spraying. Necrosis progressed to the older and younger leaves until the plants died.

One day after spraying with cyanazine/MCPA, chickweed leaves were curled in response to the MCPA in the mixture. The leaves became necrotic and eventually most plants died. Almost all of the surviving plants were those treated with 0.45 kg/ha at the early growth stage. Control in this case was variable between replicates. Contrary to observations of linuron/MCPA, cyanazine/MCPA provided better control when sprayed on older plants.

Chickweed plants treated with mecoprop showed epinastic symptoms one day after spraying. The plants grew slowly and most of them died. This treatment was most effective when

Table IV.13 Control of Greenhouse-Grown Chickweed with Various Herbicide Treatments Applied when the Plants had Four Leaf Pairs

Treatment	Rate kg/ha	Mean Score[1] 25 days	Fresh Wt. 28 days g/pot	Days from Spraying to Plant Death
Group A				
Control		0	11.3 a[2]	
Linuron/MCPA	0.1+0.3	9.0	0 c	21-22
	0.2+0.6	9.0	0 c	14-15
Metribuzin	0.15	9.0	0 c	15-19
	0.3	9.0	0 c	15-19
Cyanazine/MCPA	0.15+0.3	6.0	2.8 b	-[3]
	0.3+0.6	8.3	0.4 c	21
Mecoprop	0.45	8.3	0.2 c	-
	0.9	9.0	0 c	21
DPX 4189	0.01	9.0	0 c	25
	0.02	9.0	0 c	25
Group B				
Control		0	12.8 a	
Linuron/MCPA	0.1+0.3	7.8	3.2 cde	-
	0.2+0.6	9.0	0 f	11-14
A5633	0.4	6.5	4.3 c	-
	0.8	7.5	1.6 def	-
A5633/MCPA	0.3+0.15	4.5	8.1 b	-
	0.6+0.8	6.8	2.9 cde	-
Benazolin	0.35	7.0	3.7 cd	-
	0.7	8.0	1.2 ef	-

[1]Chickweed control was scored on a scale of 0 to 9.

[2]Numbers within columns followed by the same letter are not significantly different at the 95% level according to Duncan's multiple range test.

[3]Plants did not die before termination of the experiment.

Table IV.14 Control of Greenhouse-Grown Chickweed with Various Herbicide Treatments Applied when the Plants had Seven to Eight Leaf Pairs

Treatment	Rate kg/ha	Mean Score[1] 25 days	Fresh Wt. 28 days g/pot	Days from Spraying to Plant Death
Group A				
Control		0	19.4 a[2]	
Linuron/MCPA	0.1+0.3	6.8	4.1 b	-[3]
	0.2+0.6	9.0	0 c	25
Metribuzin	0.15	9.0	0 a	15-19
	0.3	9.0	0 a	15-19
Cyanazine/MCPA	0.15+0.3	9.0	0 a	22
	0.3+0.6	9.0	0 a	15
Mecoprop	0.45	6.5	3.8 b	-
	0.9	8.8	0 a	25
Group B				
Control		0	17.9 a	
Linuron/MCPA	0.1+0.3	4.8	10.3 b	-
	0.2+0.6	8.5	0.7 c	25
DPX 4189	0.01	8.3	1.5 c	-
	0.02	8.0	1.3 c	-
A5633	0.4	3.5	9.4 b	-
	0.8	7.0	2.4 c	-
A5633/MCPA	0.3+0.15	3.5	8.9 b	-
	0.6+0.3	6.3	3.8 c	-
Benazolin	0.35	7.0	10.3 b	-
	0.7	8.0	3.5 c	-

[1]Chickweed control was scored on a scale of 0 to 9.

[2]Numbers within columns followed by the same letter are not significantly different at the 95% level according to Duncan's multiple range test.

[3]Plants did not die before termination of the experiment.

applied at the earlier growth stage.

Plants treated with DPX 4189 showed slight chlorosis on the young leaves about 4 days after spraying. These leaves became necrotic and the plants did not grow. The lower leaves dried up and the plants treated at the early stage died. At the end of the experiment, the youngest leaves were still alive, but chlorotic, on plants sprayed at the later stage.

On plants treated with A5633, the young leaves became chlorotic and some necrotic spotting occurred about 3 days after spraying. The necrosis became more general and some plants died. When A5633 was mixed with MCPA, the MCPA caused leaves and petioles to curl one day after spraying. These symptoms disappeared and after about 8 days slight chlorosis and necrotic spotting appeared. The MCPA did not appear to enhance chickweed control with this mixture. In fact, control with A5633/MCPA was less than with A5633 alone, likely as a result of the lower rate of A5633 applied in the mixture.

Benazolin caused epinastic symptoms one day after spraying. Leaf and stem curling soon became severe. The stems turned white, nodes were swollen and masses of adventitious roots broke the epidermis at the nodes. The young leaves and flowers were very small and did not expand. Plants began to show chlorosis 15 to 20 days after spraying and many plants died. There was a greater rate response when benazolin was applied at the later growth stage than when it

was applied to young plants. The final dry weight of plants treated with benazolin did not fully reflect the degree of control achieved. The dry weights were quite high but the plants were severely deformed and would likely be killed by crop competition in a field situation.

All of the herbicides tested showed some degree of control of chickweed at both growth stages. The efficacy of most of the chemicals was not affected by the growth stage at which they were applied. Good to excellent control was obtained with metribuzin, DPX 4189, benazolin and the higher rates of linuron/MCPA, cyanazine/MCPA, mecoprop and A5633. Control was fair with the higher rate of A5633/MCPA and poor with the lower rate. The remaining treatments varied in their efficacy depending on the growth stage at which they were applied. Control with the lower rate of linuron/MCPA and mecoprop was good when herbicides were applied early, but only fair control was achieved when they were applied later. In contrast, the lower rate of cyanazine/MCPA provided better control when it was applied to the older plants than when it was applied to young plants. Control with the lower rate of A5633 was fair at the early stage and poor at the later growth stage.

Field Experiments

In 1979, all treatments except dicamba/MCPA and propanil/MCPA provided good to excellent control of chickweed that had two to four pairs of true leaves at spray

time (Table IV.15). The results were similar at both locations. The two treatments that were ineffective in 1979 were not included in the 1980 experiments. Metribuzin and DPX 4189 provided excellent control in 1980. Control of chickweed with two to three pairs of leaves was fair to good with the remaining treatments (Table IV.16), except with 0.3 + 0.5 kg/ha of bromoxynil/mecoprop which gave poor control. Plots in a second location (Table IV.17) were sprayed when the chickweed had only one to two pairs of leaves. Control of emerged plants at this location was good with all treatments except cyanazine/MCPA, but chickweed that emerged after spraying created a problem. The lack of control of small chickweed seedlings with cyanazine/MCPA in this field trial was also noted in the greenhouse experiment.

Crop injury was not observed closely because of the unevenness of the crop stand. A slight yellowing of the crop that later disappeared, was observed on some plots sprayed with metribuzin, linuron/metribuzin, cyanazine/MCPA, A5633/MCPA (1979 only) and propanil/MCPA.

Metribuzin and DPX 4189 provided excellent control of chickweed plants present at spray time and also controlled later emerging seedlings. Linuron/MCPA, cyanazine/MCPA and A5633 alone or in combination with MCPA provided good control of plants present at spray time, but did not provide residual control. Cyanazine/MCPA did not control chickweed that had only one to two pairs of leaves at spray time.

Table IV.15 Control of Chickweed in a Mixed Crop of Bonanza Barley and Park Wheat: Experiment 79A

Treatment	Rate kg/ha	Chickweed Mean Score[1] Aug 2	Chickweed Dry Weight g/m^2	Barley Yield g/m^2
Weedy control		0	20.4 a[3]	350 ab
Linuron/MCPA[2]	0.2+0.6	8.3	1.0 b	309 a
DPX 4189	0.04	8.5	0.1 b	397 bc
	0.07	9.0	0 b	410 bc
A5633	0.8	7.5	1.0 b	427 bc
A5633/MCPA	0.6+0.3	7.8	0.8 b	388 b
Metribuzin	0.3	7.8	0.1 b	473 c
Metribuzin/MCPA	0.2+0.6	8.3	0 b	406 bc
Cyanazine/MCPA	0.3+0.6	7.5	0.6 b	368 ab
Dicamba/MCPA	0.1+0.4	2.5	25.6 a	391 bc
Propanil/MCPA	1.0+0.3	3.0	24.4 a	410 bc

[1]Chickweed control was scored on a scale of 0 to 9.

[2]Sprayed 12 days later than other treatments as a result of application error.

[3]Numbers within columns followed by the same letter are not significantly different at the 95% level according to Duncan's multiple range test.

Table IV.16 Control of Chickweed in Gateway Barley: Experiment 80A

Treatment	Rate kg/ha	Chickweed Mean Score[1] July 24	Chickweed Dry Weight g/m²	Barley Yield g/m²
Weedy control		0	137 a[2]	342 a
DPX 4189	0.02	9.0	0 e	348 a
	0.04	9.0	0.2 e	390 a
A5633/MCPA	0.6+0.3	7.8	51 cd	369 a
Bromoxynil/MCPA	0.3+0.5	4.8	96 b	339 a
	0.3+1.0	6.3	71 c	371 a
Cyanazine/MCPA	0.3+0.6	7.3	74 bc	367 a
Linuron/MCPA	0.3+0.6	6.5	72 bc	354 a
Lin/metribuzin	0.2+0.1	8.0	36 d	347 a
Metribuzin	0.3	8.8	5 e	346 a

[1]Chickweed control was scored on a scale of 0 to 9.

[2]Numbers within columns followed by the same letter are not significantly different at the 95% level according to Duncan's multiple range test.

Table IV.17 Control of Chickweed in Conquest Barley: Experiment 80B

Treatment	Rate kg/ha	Chickweed Mean Score[1] July 10	Chickweed Mean Score Sept 3	Barley Yield g/m[2]
Weedy control		0		233 d[2]
DPX 4189	0.02	7.5	3.3	294 c
	0.04	9.0	5.0	277 cd
A5633/MCPA	0.6+0.3	7.8	1.5	326 abc
Bromoxynil/MCPA	0.3+0.5	6.8	2.5	374 a
	0.3+1.0	7.8	2.8	323 abc
Cyanazine/MCPA	0.3+0.6	3.0	1.0	297 c
Linuron/MCPA	0.3+0.6	7.3	3.0	288 c
Lin/metribuzin	0.2+0.1	8.5	3.3	303 bc
Metribuzin	0.3	9.0	3.3	352 ab

[1]Chickweed control was scored on a scale of 0 to 9.

[2]Numbers within columns followed by the same letter are not significantly different at the 95% level according to Duncan's multiple range test.

Mecoprop in combination with bromoxynil provided fair to good control of chickweed if a high rate of mecoprop was included in the mixture.

V. Discussion and Conclusions

Chickweed seed lost dormancy quickly when stored moist at 4°C. This condition exists in the field in early spring and fall so high germination could be expected following these periods. The optimum temperature for germination was 15 to 20°C, but good germination was also observed at 10°C. In the spring, temperatures are rising and dormancy usually has been lost under the prevailing cool, moist conditions so it is not surprising that a germination peak is observed in the spring. High temperatures inhibit germination thus fewer seeds germinate during the summer. As temperatures drop there may again be a flush of germination in the fall. Fresh seeds produced during the summer are likely to be dormant. Cool, moist conditions suitable for dormancy loss are encountered in the fall, but the temperatures following that period are low and, therefore, it is unlikely that these seeds will germinate before spring.

Nitrate added to the soil at a rate equivalent to 60 or 250 kg/ha of N resulted in germination greater than 70% in a soil low in nitrate. This could be considered in a chickweed control program. If high rates of nitrogen were to be applied perhaps timing of the application could be used to encourage chickweed germination at a time when the seedlings could be controlled.

Field-grown plants flowered 40 days after emergence and pod and seed development was rapid. The plants appeared to

be dead by mid-July but new branches arose and the plants produced a second crop of seed in September. Chickweed is well adapted to a short growing season, but it is also able to take advantage of favorable conditions in th Its indeterminate flowering habit makes control of chickweed for prevention of seed production a concern throughout the growing season. Although it is not likely that chickweed will survive as a winter annual in north-central Alberta, it was able to survive and grow at freezing temperatures in the spring and fall, thus extending its season for seed production and enabling it to get an early start in the spring.

Chickweed is tolerant of low light intensities and, therefore, can be expected to produce seed even where plants are growing under a crop stand. As light intensity increases, branching and dry weight production increase and, therefore, seed production also will increase. This, combined with its preference for moist locations, may account for the success of chickweed in gardens where crops are grown in rows that allow good light penetration, and where water is applied regularly.

Chickweed growth was decreased with increasing temperature in a growth cabinet; however, a constant temperature in the growth cabinet would be comparable to considerably higher temperatures in the field where temperature fluctuations and shading would modify the effect. High temperature is not likely to be limiting for

chickweed growth in Alberta but it seems unlikely that the weed will spread into the southern part of the province as it does not adapt well to low soil moisture conditions.

In pot experiments, chickweed showed the ability to reduce barley yields, especially when it emerged 2 weeks before the barley. Under common agronomic practices in north-central Alberta, weeds emerge at about the same time as the crop except in the case of winter annual crops which are not common in this area. Chickweed was not nearly as competitive when it emerged with the barley but increasing density increased its competitiveness. In many farmers' fields where chickweed is a problem, it emerges at very high densities and could, therefore, result in losses in barley yield. No field studies were undertaken, but observations of rapeseed in competition with heavy stands of chickweed confirmed that the weed could reduce yields of that crop in the field.

Wet conditions that prevent or delay spraying operations are ideal for chickweed growth and may result in crop yield losses where the weed is not controlled. Regrowth of chickweed in the fall can also cause mechanical problems in harvesting operations. If combining is delayed due to wet weather, such as in the last few years, chickweed will grow through the swaths and make it difficult to pick them up later.

Chickweed has become a serious problem to farmers in north-central Alberta in recent years. It is well adapted to

growth in this climate as the period from emergence to seed production is short and it is able to survive freezing temperatures. Chickweed does best in cool, moist locations so it is not likely to become a serious problem in southern Alberta, except possibly in irrigated fields. It does not survive as a winter annual in north-central Alberta and therefore its competitive ability is limited somewhat as it needs a head start for maximum competitiveness with barley.

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